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Volume 39 Number 8

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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MOBILE ARMAMENT FOR DEFENSE

By ANDREW M. COYLE, NEW YORK, N. Y.

Member of the Society

BROADLY speaking, the subject "Mobile Armament for Defense" would cover every weapon and engine capable of being transported from place to place and used to repel an enemy. I shall, however, confine my remarks to one important branch of land equipment—to those weapons and engines which have been recently developed and present points of novelty both in construction and military value, namely, armed and armored automobiles and railway cars, and heavy mobile guns. These are all in process of development and offer many problems for the engineer.

The prospect of valuable development along these lines is particularly good in this country, for the reason that we are starting with a clear field. We are not bound by types which, constructed under emergency, have to some extent become fixed in the armaments of other countries. We are free to select the best types so far developed and to add thereto the finishing touches of American design.

It is my purpose to point out briefly the general features of the several types of mobile armament which have been developed in Europe, so far as the meager information obtainable permits. Also to explain the simple mechanics involved in the problems presented. I shall, of course, not attempt to describe the armaments now being designed and built by the War Department of the United States. I hope, however, that some of those present will study the problems and be ready to render practical assistance in the work before us.

War in Europe has assumed many of the aspects of a siege. In this country the same condition could not exist, for the reason that we have not the same density of population. We must, therefore, be prepared for the greatest possible mobility of our army and the highest efficiency in our mobile armament.

Our coast line is of such extent that it cannot be defended by any navy we are likely to build or would be able to maintain. Our important harbors, will, of course, be protected by permanent works, but for the defense of all the rest of our coast, we must depend, after the Navy, upon heavy mobile armament. The medium and light mobile equipment is a strong—I might say almost indispensable—adjunct to land operations.

I must digress at this point to comment on the singular mental attitude of some of our good citizens who even today do not realize the imperative necessity of complete military equipment.

Right thought is the foundation of all progress. The first step, therefore, toward mobile armament is to mobilize the wits of our people. If we could only lay hold on the thoughts of these complacent locally minded people—place them on wheels—or even wings—as the Army is doing with our guns, if we could cause them to travel north, south, east and west over our land and to comprehend that this is a land of States United and that it behooves each individual to sacrifice something for the common good, we would accomplish a mobile armament of greater national value than that which shall be wrought in bronze and steel, important as that is.

THE MILITARY IMPORTANCE OF GOOD ROADS

The next important step toward mobile armament is the roadway. The day of field artillery has not passed. The types of carriage and limber which we saw pictured in our school histories as drawn by dashing horses through furrowed lanes and ploughed fields or by men laboriously up mountain sides, are not to be thrown on the scrap heap, though, when possible, motors will take the place of animal power. Roadways are more important in warfare today than ever before. Great military operations have always followed roadways, and as equipment becomes more and more cumbersome and beyond the carrying power of man and beast, roadways must be ever more carefully looked after.

This second step in mobile armament is one of even greater economic than military value. It is difficult to think of any part of the country in which railroads and roadways constructed with reference to military utility would not be of the greatest commercial advantage. At present our avenues of transportation are established mainly with reference to immediate business requirements. Under other conditions they might be established upon a general and comprehensive plan.

I have already mentioned the impossibility of protecting our coast by fixed fortifications. The Navy having been overcome or outmaneuvred, there are a great number of places on our coasts where an enemy could make landing in force—places where, under the protection of the enemy's fleet, thousands of men could be landed in a few hours. While in time of war

This paper points out the general features of the several types of mobile armament which have been developed in Europe, as an aid to the engineers of this country who will now have to take hold of the problem of developing this means of defense.

The author emphasizes the importance of the roadway, a factor which must be carefully looked after and in the direction of which an enormous amount of work remains to be done.

He reviews the history of the armored and armed automobile from the inception of the common automobile provided with slight protection and armed with a machine gun, to the present "tanks." He also describes the development of the armored railway car.

The paper concludes with a description of the various methods proposed for meeting the requirements of heavy mobile guns. Of interest are descriptions of a new system of recoil for mobile guns and the author's non-recoil coast-defense gun, in which latter the breech block abuts upon a hardened steel spherical segment and the reaction at the time of explosion is transmitted to a heavy concrete foundation as a static load.

Abstract of paper presented at a meeting of the New York Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, March 13, 1917.

each of these places is a point of danger, in time of peace many of them are possible harbors. The same roadways which would transport mobile armament would open these harbors to traffic.

Parallel to our eastern coast we already have trunk-line railroads. It is a matter of no great difficulty to extend branch roads to the points of greatest strategic importance and to make surveys and all necessary arrangements to enable our military engineers to construct other branches on short notice. The difficulties are mainly legislative and political. Before this plan can be inaugurated, however, many questions must be settled both as to right of way and as to methods of operation and maintenance. These branches should, if possible, be operated so as to yield a profit.

Within the past few years we have made enormous improvements in our wagon roads, but there remains an enormous amount of work to be done. Here again we find the necessity for coöperation between the national and local authorities.

Obviously, every trunk line and branch should be paralleled by a wagon road capable of standing heavy traffic. By parallel I do not imply proximity. For many reasons it may be desirable to have the trunk lines some distance apart in order that the lines may be separately defended.

Our bridges must be carefully considered. We need many new bridges, and they should all be strong enough to permit of the transportation of heavy ordnance.

For forty years the subject of good roads has been agitated for economic reasons. Let us hope that the present movement toward military preparedness may cause this good work to take definite form and go forward.

We now come to the consideration of the armaments which shall pass over these good roads—when we have them built, or which may have to struggle along on some of the roads as they already are. The defence of the nation will depend upon the equipment of the army. The day when men could be called hastily into action is passed. Numbers and valor count for but little against equipment.

ARMORED AND ARMED AUTOMOBILES

The first machines developed were common types of automobiles provided with slight protection and armed with rapid-fire or machine guns. The rapid-fire gun is necessarily of small size (about one pound), for the reason that the recoil of a heavier gun would be too much for the car. This type of machine is very effective for guarding roadways and may participate in offensive movements, provided it can be operated from some point of safety. The shields protect only the gunners and not the working part of the machine. Its use is to carry these light guns rapidly from point to point. It is not possible to armor automobiles against anything heavier than a rifle bullet, for the reason that armor plate of sufficient weight to withstand even a 1-lb. projectile would make the machine too heavy for service.

These light armored automobiles were improved upon by the British, who developed heavier cars with turrets. These cars were not of graceful design, but are said to have done excellent service. The gunners are well protected, but the running gear is not protected at all. The advance of these machines may be stopped by concentrated fire on the running gear.

The Italians later developed turret machines of more graceful design. At first no attempt was made to protect the running part of the machine, but the gun and gun crew were very well protected; in fact, the machine is a small fort on wheels which can be quickly transported from place to place, but it always will be necessary to use it in a road "cut" or behind some barrier which will protect the running gear from damage. A shield of light armor plate is provided over the engine and furnishes fairly good protection.

In a later Italian machine the wheels are protected. Bars in front are provided to cut barbed wire. These two types of Italian machines are said to be the latest and best types of armored automobile. They are certainly the best in appearance.

The French have developed machines specially designed to carry a Schneider anti-aircraft gun, which is mounted upon the rear of the machine. The gun used on such machines is necessarily small and would not be able to reach an aircraft at a high elevation, but the extreme mobility of the gun renders the outfit a very effective weapon. The Schneider recoil system is very efficient. As the range of elevation of these guns is from zero to zenith, they are effective in any situation and the term "anti-aircraft" is to some extent a misnomer.

The French have made successful use of motor trucks for transporting small howitzers. The howitzers are not fired from the trucks but are skidded off when they are to be put in action. This operation may be accomplished in about the same time it would require to unlimber regular artillery.

The skid-mounted howitzer is a very convenient arrangement—it may be fired from all sorts of positions, from the trenches and from behind low breastworks. When the howitzers are at work the trucks are out of the way. The motive power is withdrawn out of range just as in the case of horse-drawn guns. If the guns remain long in one place the trucks are available for other purposes.

The Davis non-recoil gun is interesting as being the only weapon so far developed which does not react when fired. This result is accomplished by firing a charge from both ends of the gun. That fired toward the rear being of shot and vaseline, breaks up soon after leaving the gun. A round of ammunition for this gun weighs about one and six-tenths times as much as a round of ammunition for a 3-in. field gun. The energy imparted to the Davis 12-lb. projectile is about one-third of the energy represented by the 15-lb. projectile fired from a 3-in. field gun.

If we compare the work done by these two guns on the basis of the amount of energy delivered from the muzzle, it will be seen that the amount of ammunition necessary to be carried to produce a given quantity of muzzle energy is as 4.8:1.

If any way can be found to lessen the reactive force due to recoil without greatly increasing the distance of recoil, it will be of material advantage. In this case the method is so wasteful of material that it is only practical to use it in very extreme cases. I will speak further regarding the question of recoil.

Under the head of automobiles we may consider the "tanks" which have been used by the British. Their primary purpose is for direct frontal attack. They are sufficiently powerful to break down barbed-wire entanglements and will cross trenches, provided the trenches are not very large and the ground about them is solid. But the weight of these machines is so enormous that they will crush in anything but the most substantial ground. The remarks about the weight of armor which can be used on automobiles apply to some extent to these tanks. A direct blow from a 15-lb. projectile will put the tank out of commission. Their armor is heavy enough to withstand glancing blows from quite heavy projectiles. The progress of one of these machines is necessarily rather slow and the enemy should have time to bring into action guns of sufficient size to disable the tank before it has gone very far. I do not think that machines of this kind would be of any use in this country, although they have been of some value on level fronts in northern France.

The new "tanks" of French design are made to crush

through wire entanglements. They have abandoned the trench-crossing scheme tried by the English, which has evidently turned out to be of little value.

ARMORED RAILWAY CARS

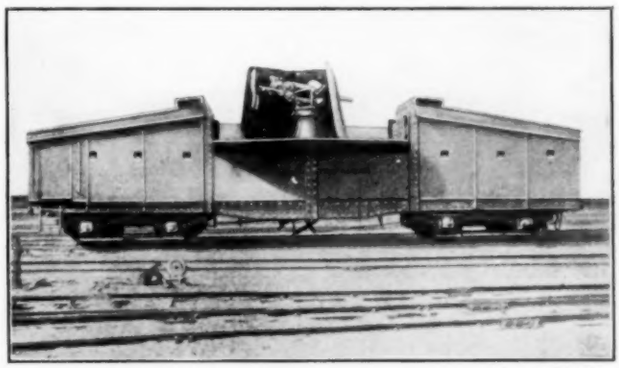
The first armored railway car ever used in warfare was constructed in this country. It was built under the orders of General Robert E. Lee, who was an engineer officer and at an early stage of the Civil War saw the value of this equipment. During the Boer War the British developed an armored car (Fig. 1) which is interesting as being the prototype of the modern car of the U. S. Army. The car is divided into three compartments. Those at the ends afford protection to riflemen. The central compartment, which is lower than the ends, is the magazine. Upon the top of the magazine is mounted a 3-in. naval gun.

Complete trains are formed of cars carrying guns accompanied by box cars carrying ammunition and light armored cars. Outriggers are provided for stabilizing the gun cars. Some stabilizing device has to be used on all cars from which guns of large size are to be fired. When in operation, the heavy guns are separated from the rest of the train, the armored cars being used to protect the track against surprise attacks.

The first modern car built in America (Fig. 2) was constructed on short notice when trouble with Mexico was anticipated. It is a steel box erected upon the platform of a railroad car of standard type. The stakes of this car afforded an excellent support for the steel plates. The port holes are for rifle fire and machine guns. In the center of the car is a well in which a 3-in. field piece is mounted upon a special carriage. The peculiarity of this carriage is that the gun is traversed in azimuth about a center which is nearly below the breech of the gun instead of below the trunnions as would be the case in a attacks by the enemy. Of course, an armored car operating on such duty cannot go far from its base, otherwise it would be liable to capture, as is the case with any other detached unit.

The motive powers available are storage batteries, motor-generator sets operated by Diesel or other internal-combustion engines, steam and also direct-connected gasoline engines.

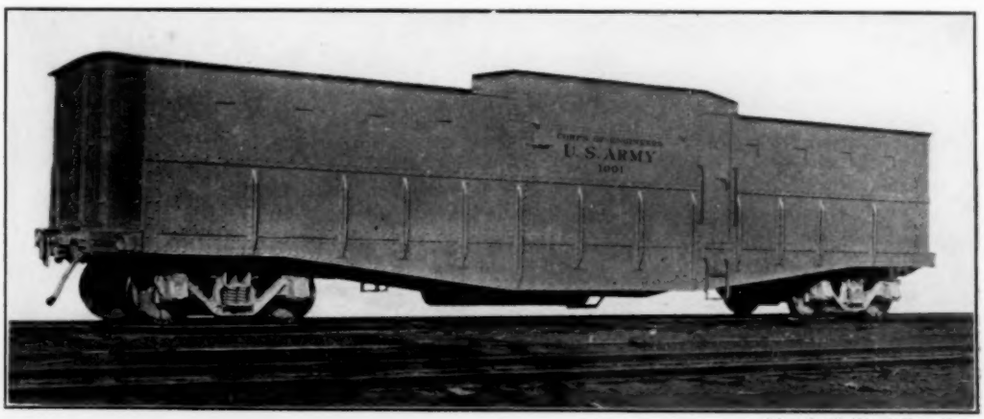
There has also been developed an arrangement of a gasoline motor suitable for driving an armored car, or, for that matter, any other car. In this construction the middle sill of the car is replaced by two very deep girders separated about six feet. The gasoline engine is of the V-type and should be of not less than 100 hp. It drives the car through a jointed transmis-



Engineering.

FIG. 1 BRITISH ARMORED CAR WITH 12-LB. NAVAL GUN MOUNTED IN CENTER

sion similar to that used on large motor cars. The location of the joints used in this shaft is such that the movement of the truck about the car center is in no way interfered with. The reverse gear is operated in the gear case which is on the wheel



Standard Steel Car Co.

FIG. 2 FIRST MODERN ARMORED CAR BUILT IN AMERICA

pedestal mount. This arrangement provides a clear space back of the gun in which the crew can work and avoids the necessity of extended platforms such as used on English and French mounts.

There are being designed some new types of armored cars which embody great improvement on those shown. I, of course, am not at liberty to show these designs.

It is highly important that an armored car should be provided with independent motive power. While these cars are sometimes used in trains, their most valuable service can be rendered independently, each car patrolling a certain portion of railroad and being continually on the lookout for surprise shaft, and the pinion may be thrown out of mesh so that when the car is connected up in a train there is no idle machinery in motion. Within the space of this deep center girder the oil tanks, air brake and other vulnerable parts may be located, the web plates of the girder being made of sufficient thickness to resist penetration.

Before discussing next class, I will call attention to a new type of coast gun which is not mobile.

Fig. 3 is a coast gun. The peculiarity of the gun is that the breech block does not screw into the gun and that the gun does not recoil. The breech block is a simple plug provided with a gas check. This block abuts upon a hardened-steel

surface which is curved, the curve being concentric with the trunnions of the gun. The reaction at the time of explosion acts as a static load upon the abutment. There is no mass in motion. The abutment member is traversed in azimuth in a casting which is a spherical segment. The concrete foundation must be sufficiently massive to stand the static load imposed.

The projectile is brought to the gun upon a carriage which travels about the center of the mount. The power to traverse and elevate the gun, also the electric wires, are brought through a conduit which terminates at the center of the mount. This gun does not disappear, but the splinter-proof housing is small and inconspicuous, and may be concealed from the enemy until he is within close range. The gun has all-round fire and may be elevated to any desired angle up to 30 deg.

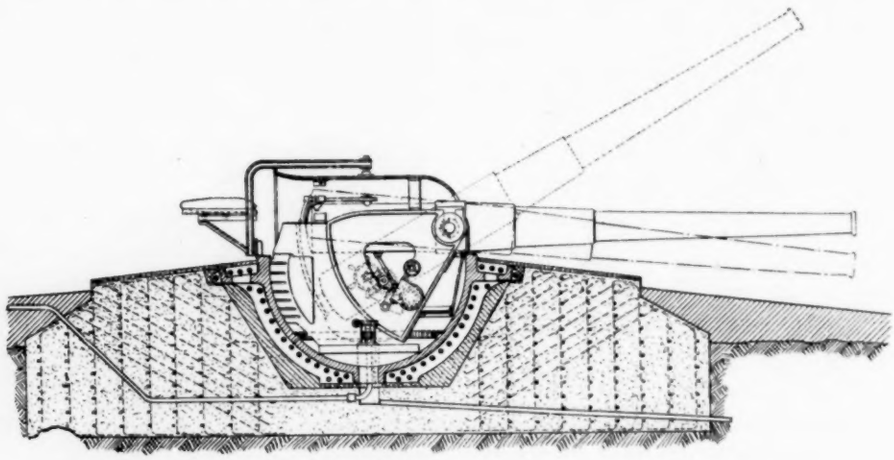


FIG. 3 SECTION OF COAST-DEFENSE GUN WITH SPHERICAL MOUNT

HEAVY GUNS ON RAILWAY MOUNTS

We now come to the most important railway armament, i. e., the mounting of heavy guns upon railway cars. We may divide this equipment into two classes: First, guns of high power to be used against vessels at sea. These guns are necessarily fired from locations which have beeen carefully predetermined and to some extent prepared. They are never fired from main-line railway tracks. The second comprises guns of from 4.7-in. to 8-in. caliber and is useful to prevent landing or to check the enemy if he has made a landing.

In their operations in Belgium the Germans used large howitzers which were not originally mobile weapons. They were fired from previously prepared foundations. When placed upon such a foundation the fire of a gun is, of course, much more accurate than that of a mobile gun. The best foundation is of concrete, but a more quickly constructed foundation may be made of heavy timber bedded in clay, sand or cement. A foundation of this kind will stand a number of shots before it gets seriously out of level. These guns are transported, either assembled or in parts, upon flat cars. They are lifted off and placed upon their foundations by ordinary cranes and may thus be considered as a part of mobile armament.

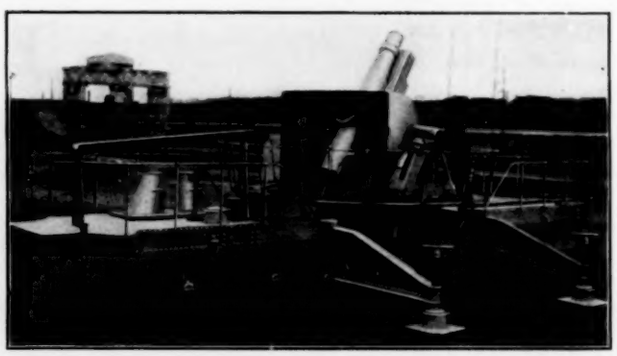
Fig. 4 shows a car of French design carrying a moderate sized howitzer. It is necessary to use outriggers in order to stabilize the car when the howitzer is fired. As depicted, on level ground this system works out very well. If the ground is not level, footings must be built up to receive the jack screws. There is provision under the car for locking to the track, so as to resist movement in a horizontal direction. The tendency is for the car to be lifted from the tracks. The center of action is the point of the jackscrew. Should the track shift there is, of course, a tendency to bend the screw, which may result in trouble if the screw is extended.

A railroad track will not resist a very great force applied transversely. About 30 per cent of the load on the track is a maximum. As the tendency is to lift the car when the gun is fired horizontally, the full weight of the car cannot be considered in making allowance for the resistance of the track.

SCHEMES FOR MEETING THE REQUIREMENTS OF MOBILE GUNS

We may now consider some of the schemes devised to meet the requirements of mobile guns.

In Fig. 5 the system of outriggers used on the French car just described is shown at (*a*). It will be seen that if it is fired from a location when the ground on one side of the track is sloping, a certain amount of blocking will be necessary. The overturning moment is A/B; the center of action is at C. Another arrangement is shown at (*b*); the outriggers are nearly on a level with the car platform and are supported by struts or jackscrews which are free to move about the centers C, C'. The overturning moment is A/B. The entire side thrust must be provided for on the track. The tendency to bend the jacks is eliminated. If the ground beside the track is low, the jacks are lengthened, no blocking being required. At (*c*) is shown a system of blocking the car upon the railroad ties. The base B is short, but if the car is heavy, a good-



Illustrated London News.

FIG. 4 FRENCH CAR CARRYING HOWITZER

sized gun may be fired from a car blocked in this way. It is certainly very desirable to work within the limits of the roadbed, as we are then fairly certain of the conditions we shall find, and know that we can fire the gun from any point along the road without previous preparation.

When we fire a gun horizontally, the center of action may be kept low, but when high-angle fire is required, we find some difficulties. The trunnions must be placed higher, not only to allow for the actual swing of the gun, as shown at (*d*) in Fig. 5, but to allow for the recoil as shown at (*e*). This increases the overturning moment when the gun is fired horizontally.

This principle of double recoil is important in mobile armament. The car is blocked, as shown at (*c*) in Fig. 5. A car blocked in this manner will stand a very great force applied downward. Its horizontal stability is, however, much less. The principle of double recoil involves the use of one recoil system parallel to the axis of the gun; this system offers heavy resistance, the movement being quite short. The carriage is free to recoil in a nearly horizontal direction upon a long slide. The resistance to the horizontal recoil is not great enough to affect the stability of the car. This principle was used in some of the older types of carriages in which the recoil along the slide was inadequate and the carriage was allowed to recoil horizontally, being checked by a friction brake or a "brake cylinder."

It has been found convenient to develop several formulæ for determining approximately the working strains and distances of recoil which will govern the mounting of a gun for double recoil.

For free recoil of the gun,

$$V = \frac{v\,p + k\,w}{M} \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

Where V = velocity of recoil of gun if unchecked
v = muzzle velocity of projectile
p = weight of projectile
w = weight of powder charge
M = weight of gun.

For smokeless powder k may be taken at from 4000 to 4700. For double recoil the formulæ are:

$$A = P\cos\phi - R \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

$$z = \frac{VAM}{PN + AM} \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

$$y = \frac{x^2}{2g}\left(\frac{N}{A} + \frac{M+N}{R}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

$$x = \frac{Mv^2 - (M+N)x^2}{2gP} \quad \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

where N = weight of carriage or car
P = resistance of gun recoil system
R = resistance of carriage recoil system
A = accelerating force acting on carriage
ϕ = angle of elevation of gun
x = velocity of combined recoil
y = distance carriage recoils
z = distance gun recoils on its slide.

When a gun is fired, the gun and projectile move in opposite directions, in accordance with Newton's third law of motion, their relative velocities being inversely as their masses. We have also to take into consideration the effect of the powder. The gases leave the gun at a velocity much higher than the projectile. All problems in gun recoil begin with the theoretic velocity of free recoil.

Formula [1] is used to find the value of V, and k is a constant which has to be determined for each kind of powder.

Formula [3] expresses the velocity of combined recoil, that is, the velocity reached when the gun and carriage are moving together.

The other formulæ are for determining the length of the recoil of the carriage when checked by a known resistance and the length of recoil of the gun in its slide. They are not accurate, as they are based upon the supposition that the resistances are constant, but they give results sufficiently accurate for preliminary calculation.

As applied to the problem of mounting guns upon railroad cars in accordance with the system of double recoil, just explained, the formulæ are used as follows:

The resistance of the first recoil system P must be such that when the gun is fired at the highest allowable elevation, the vertical component of the reactive force will be within the bearing capacity of the car and roadbed. The resistance may be made great, for the reason that the car may be solidly blocked upon the road, and will withstand a considerable vertical load. A is the horizontal component of the force P,

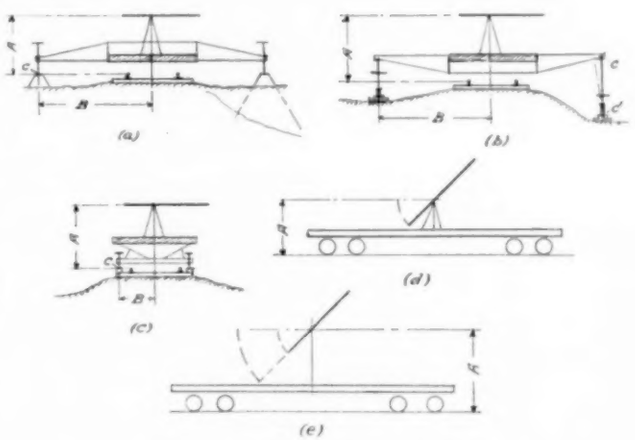


FIG. 5 DIAGRAMS SHOWING METHODS OF STABILIZING

which tends to impart motion to the carriage and is found by Formula [2].

It is obvious that the resistance R must not be great. It must be so small that it will neither overturn the car nor shift the roadbed or other anchorage. It appears to me to be easier to provide a long horizontal recoil than a special anchorage.

Having determined these conditions, we find that after the gun is fired the velocity of the gun recoil is checked and a certain velocity is imparted to the carriage. The force P being great as compared with R, a point is soon reached when the gun and carriage are moving with equal velocity. From this point they may be treated, for practical purposes, as a single mass in motion. The gun will, of course, have some further motion on its slide, but this will be negligible as compared with the long horizontal recoil of the carriage.

The weights of the car, gun and carriage being known, and the values of P and R determined with reference to conditions of strength and stability, the length of horizontal recoil for which allowance must be made is easily determined by Formula [4], which gives the value of y.

It has been proposed to mount heavy naval guns upon specially designed cars, and to provide at suitable points concrete foundations, with locking devices, to engage the coöperating members on the cars, thus providing stable bases from which to fire the guns. The objection to the system is the initial cost and the difficulties met in securing the sites for the perma-

nent foundations and in maintaining them; also the fact that these sites will be mapped and known to the enemy.

Another system contemplates firing guns from a car moving on a curved track. The gun has a slight traverse on the car, but the main traverse in azimuth is secured by moving the car on the track. The gun being fired, the car recoils along the track. This is very objectionable for the reason that the gun has to be re-aimed after every shot. Thus you lose the advantage of a good shot. I do not think the system would be of value against a moving target.

Fig. 6 shows a gun of rather peculiar design mounted upon a railway car the trucks of which are arranged so that they can be completely turned under the car. This gun is fired from a track shown below. When being made ready for action, the front truck of the car is switched on to the curved track. The switch is then thrown so that the rear truck passes on to the straight part of the track. Traversing gears are provided

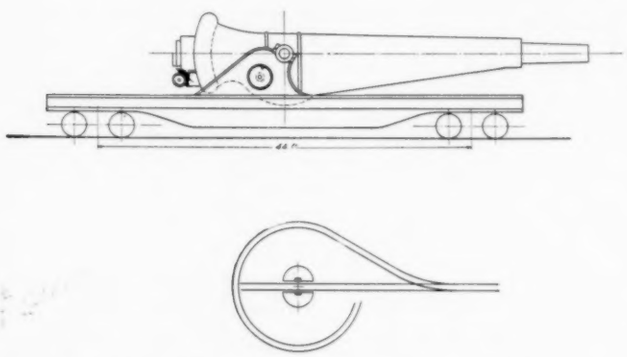


FIG. 6 GUN WITH SPECIAL RECOIL DEVICE MOUNTED ON RAILROAD CAR, AND CIRCULAR TRACK FOR TRAVERSING THE CAR

on the trucks so that the car may be worked forward until the rear truck is at the center of the system. Here an anchorage is provided of sufficient strength to sustain the reaction due to the recoil. The forward truck is traversed on the curved track about the center. The car is thus made to serve as a turntable. The gun fires from a fixed position. When the gun is elevated the breech swings down through an opening provided in the car platform. This arrangement brings the axis of the gun low for horizontal fire.

The laws of action and reaction are fixed, and it may be reasoned that no way can be found to lessen the shock of recoil excepting by making the recoil long. The case shown about this gun does, however, contain a mechanism—which, for obvious reasons, I am not free to explain—which does, to a great extent, lessen the shock of recoil, and the gun does not move back from the position shown when it is fired. The normal energy of recoil of a 14-in. gun is over 3,000,000 ft-lb. —enough to crush any ordinary railroad car or to lift it over a good-sized building. With the mechanism I have spoken of, the thrust upon the anchorage is only about 80,000 lb.

The first gun mounted upon a railway truck was mounted in the United States. This was done by the First Connecticut Artillery during the civil war. It was an old-time mortar, mounted on a truck. Five shots were fired from this gun before the truck collapsed. After that it was carried about on a flat car and fired from fixed platforms. Originally it was fired from a curved track.

[The paper from which this article is briefed was delivered prior to the entrance of the United States into the war. Although the work of mobile defense may for the time be set aside in consequence of the more pressing business of attacking the enemy, it is a work which must be carried out in the long run, and should be carried out so far as possible even during our present military exertion in order that no future emergency may find us unprepared.—THE AUTHOR.]

War is a vast country-wide engineering enterprise. Theoretically speaking, an all-wise and powerful board of experts should determine where each man should be posted in the great war chain of fighters, for it is obvious that all specially trained men, and particularly all technically trained men, should keep at the posts where their training is needed. It was an inevitable mistake made by our allies at an earlier stage in the war which led many young physicians, engineers, mechanics and valuable specialists to rush as volunteers for the front. The technically trained men should be kept at their profession unless there happens to be a superfluity of them. The junior men in colleges, and particularly in technical or medical colleges, will probably serve their country better by working hard at their educational preparation than by abandoning their college work before their training is completed.—*The Electrical World.*

What is turning out to be a great storehouse of ammunition and explosives is being prepared by the Bethlehem Steel Company in New Jersey between Mays Landing, in Atlantic County, and Petersburgh, in Cape May County. This stretch of territory is more than forty miles long, stretching from north to south some five miles in width, on an average. It will afford ample space for testing good guns as well as for the storing of explosives and ammunition. More than 1000 men have been at work for a month in erecting the buildings, and the company is constructing its own railroad over the long stretch of territory, and the Government has given authority to build a new bridge across the Tuckahoe River. During the last ten days more than 150 freight carloads of ammunition have been brought into the grounds and stored. No strangers are admitted to the territory, which is surrounded by high barbed-wire fences, and the whole distance is patrolled by a company of soldiers to prevent trespassing. (Philadelphia *Public Ledger*, June 6, 1917, p. 7.)

Contracts have been let for the construction of a wind-tunnel building at Throop College of Technology, where researches in aerodynamics will be carried on. Here interesting and valuable experiments with airplanes will be conducted under the direction of Dr. H. Bateman, recently arrived in Pasadena from Johns Hopkins to take up this line of work, in which Throop College is one of the pioneers. The work takes on added significance from the recent announcement by the War Department of the plan to send an army of aviators abroad.

Dr. Bateman, who will have charge of the work, is a mathematical physicist, and his immediate investigations will relate to the stability of airplanes during flight, with which study the mathematical study relating to aeronauties is chiefly concerned. This aeronauties laboratory has been designed in consultation with Government experts in Washington and experts of the Curtiss Company in Buffalo, and the wind tunnel and apparatus to be used in connection with it represent the latest ideas in laboratory study of the science of aviation. (*Christian Science Monitor*, July 14, 1917, p. 8)

PROBLEMS IN WASTE DISPOSAL

By HENRY A. ALLEN, CHICAGO, ILL.

Member of the Society

THOUGH the questions of disposal of wastes have been under consideration for many years, it is comparatively recently that such have been submitted to careful engineering study and analysis.

The main factors to be considered in the disposal of municipal wastes are sanitation and discommodity—the first as affecting the health of the individual and of the general public, the second as affecting the individual or public in the matters of inconvenience, unsightliness and offensiveness.

Cost. This factor is put last because it is assumed that any legislative body, appreciating the necessity of a function, will provide funds for the actuation of that function.

Often conveniences are demanded by individuals or the public, in utter disregard of the fact that such can not be had without commensurate expenditure of funds.

Economy in public works does not mean the apparent saving in moneys by the non-execution of a desired or required public improvement (so to speak, municipal deferred maintenance), but making each dollar appropriated go farthest in the execution of a necessary or desired public improvement.

Obviously, it is to the engineering professions that the public must turn if it is desired to have solved, in a logical and practical manner, the various intricate problems of municipal waste disposal.

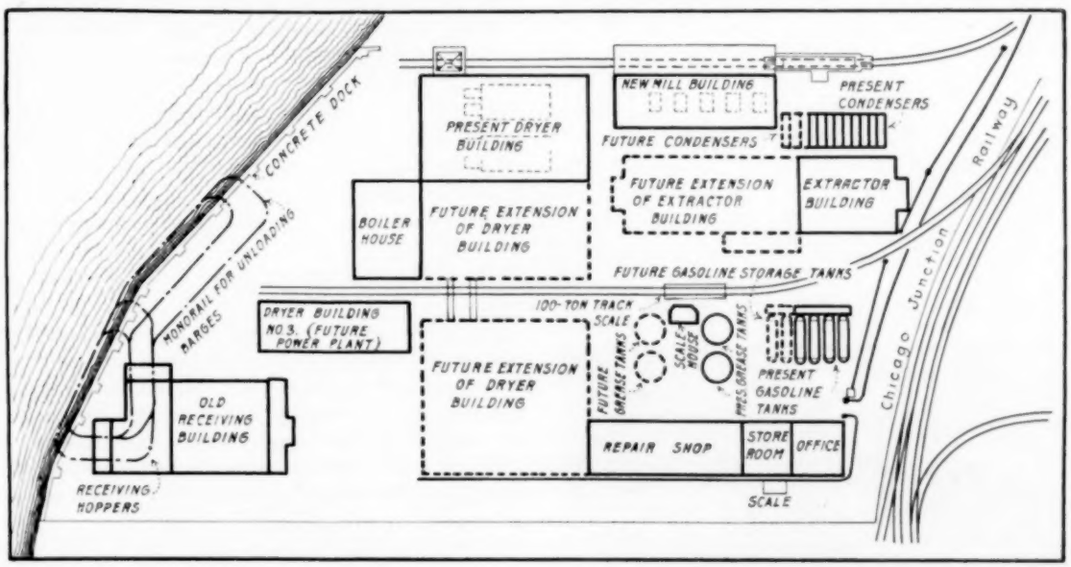


FIG. 1 CHICAGO MUNICIPAL REDUCTION PLANT WITH CONTEMPLATED EXTENSIONS

In designing for a municipality, it is my opinion that the work should proceed along the following general divisions stated in the order of their importance:

FACTORS TO BE CONSIDERED IN WASTE DISPOSAL

Service. Service requires that the apparatus and structures shall at all times be able to perform the duties imposed. In the case of waste disposal it means at all times required ability to collect, transport and dispose of in a convenient and sanitary manner all wastes produced.

Discommodity. Discommodity or inconvenience relates to handling in a manner least disagreeable to, and entailing minimum effort on the part of, the individual or public.

Attractiveness. Attractiveness in structures is desirable as its tendency is to make less acute any actual or imaginary odium attached to a plant, whereas neglect tends to magnify such.

Economy of Operation. Economy of operation refers to the accomplishment of the work required in a most direct and inexpensive manner, having in view the obtaining of the greatest net monetary returns compatible with good sanitary and inoffensive operation.

THE MUNICIPAL WASTE SITUATION IN CHICAGO

As the municipal waste situation in Chicago is typical of similar situations in many other cities of the United States, the following brief account may be instructive:

On August 30, 1906, the city of Chicago entered into a contract with the Chicago Reduction Co. for the disposal of the city's garbage.

The laws of the state of Illinois permit contracts to be entered into at any time of the year relative to the disposal of garbage, provided the duration of such does not exceed five years.

Owing to change in the system of disposal, at the end of two years a new contract was entered into for a period of five years ending August 31, 1913, which provided for a payment by the city of $47,500 per annum to the contractor.

During this period it was claimed by the Chicago Reduction Co. that the city did not live up to its contract, and by the

Abstract of paper presented at a meeting of the Chicago Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, January 19, 1917.

city that the company did not operate its plant in a sanitary and inoffensive manner, as contemplated by its contract with the city.

Much dissatisfaction having arisen in regard to the manner of operation of the plant during the latter part of the term of contract, many individuals and civic associations began agitation for improvement of conditions, which finally resulted in an appraisal of the plant being ordered. A board of appraisers was appointed, consisting of H. M. Byllesby & Co., represented by Mr. Harold Almert, myself, appointed by His Honor the Mayor, City of Chicago, and Mr. Leonard Metcalf, selected by the two appraisers of the contending parties.

There was practically an agreement by all appraisers as to reproduction cost new; but a great difference in the question of physical depreciation, the city's appraiser estimating 41 per cent at the end of the five-year period, Byllesby & Co. 14 per cent, and the third appraiser a mean proportional of 24 per cent. The final fair values arrived at were approximately as follows:

City's appraiser	$226,000
Company's appraiser	762,000
Third appraiser	492,000

The company's appraiser agreed to the value of the third appraiser, but, as the city's appraiser considered this juggling, he withdrew.

After the disagreement of the appraisers, the city having

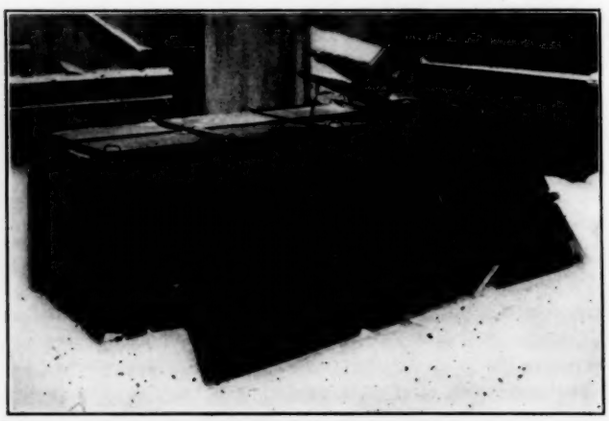


FIG. 2 GARBAGE BOX USED IN CHICAGO
(Length, 12 ft.; width, 4 ft.; depth, 32 in.)

no place to dispose of its garbage, I was asked to erect in two weeks' time a temporary garbage plant capable of handling a maximum of 500 tons a day until the city could make other arrangements. This work was accomplished, and, while not entirely inoffensive in operation, served well its purpose until the purchase of the plant of the Chicago Reduction Co. by the city.

Condemnation proceedings were commenced shortly after the appraisal of the property, but before they were completed, early in 1914, the company made a proposition to the city to sell its plant, including real estate, good will, etc., for the sum of $275,000. I previously advised against the purchase of this plant by the city, appreciating that rehabilitating an old plant and adding new structures while operating would result in high cost, and that when completed the plant would not be as well arranged and equipped as would be the case in a new plant constructed on a clear piece of ground.

Owing to the difficulty of securing a suitable location for a new plant, however, it was decided by the city to purchase the plant at the price offered—$275,000. In my original appraisal I estimated the worth of the plant to the city as the value of the land, plus salvage or scrap value, plus value of supplies on hand, plus an amount that may be termed the "value of temporary utility" or "availability for temporary use value," making a total of approximately $226,000. As this was in October and there were available approximately seven months before the hot weather of the following summer, I estimated the "temporary utility value of the plant" at approximately $80,000. When the offer from the Chicago Reduction Co. to sell was made, there remained practically but three months before the hot weather, too short a time to construct a new plant, hence I estimated an increase of $25,000 in "temporary utility value." As the cost to the city of condemnation proceedings would undoubtedly have been not less than $25,000, and in view of the fact that the property so obtained could be used for no other purpose than that for which condemned, I advised, all conditions being considered, that the company's offer be accepted.

It was during the bad weather of February 1914 that instructions were issued to start the work of rehabilitating the old reduction plant purchased from the Chicago Reduction Co. This necessitated the work of design and construction being carried on at the same time and working night and day. By June the plant was in condition to, and did, handle all the garbage of the city of Chicago in a practically inoffensive manner.

One of the greatest difficulties in disposal problems is the location of loading stations and plants, or, more strictly, the being permitted to locate such. While the citizens appreciate the necessity for disposal and attendant plants, they prefer such situated in their neighbors' back yards and offer strenuous objections when their own are under consideration. Hence, locations are too often required decided by political expediency rather than by good engineering judgment.

It is well to state here that the women of Chicago, through their various organizations, have played a most prominent part in bringing about the solution of the city's waste question, especially as regards garbage. These organizations are of invaluable assistance in educating householders to properly separate and take care of household wastes.

In my opinion, the city of Chicago has approached this great question in a most broad-minded and businesslike way, appropriating requisite funds to enable investigations, studies and experiments to be made, to the end that a foundation can be laid for the solutions of the various problems—not alone for today, but for years to come.

SELECTION OF A GARBAGE-COLLECTION UNIT

Having been selected chief of the technical staff, created on the recommendation of the city's Waste Commission, the necessary engineering and working forces, including waste investigators, were organized and systematic studies begun. At the same time, work on the design and construction of the municipal reduction plant, 95th Street incinerator, Bridewell crematory, and collecting and handling equipment was being carried on. To facilitate this work it seemed to me that somewhere along the line from the production of waste to the point of final disposal a unit should be selected. The most difficult phase of the entire problem is getting the garbage from the kitchen to the collecting unit.

It was for this reason that the garbage box was selected. The larger the capacity of this unit, other things being equal, the less the cost of collecting and handling. Study showed that

a six-cubic-yard box when filled became too heavy for a two-horse team, except on the very best of paved streets. As but 13 per cent of our alleys are paved and 62 per cent of our streets, this prohibited such a unit being used throughout the city. So, taking all in consideration, the unit adopted appears to be the most satisfactory. This consists of a box 12 ft. long, 4 ft. wide, and 32 in. high, as shown in Fig. 1.

Two such boxes can be loaded abreast, three in length and two vertically, making twelve boxes per specially designed railway car. One-half this number can be loaded on a specially designed street car. The net loads of garbage contained will be approximately 34 and 17 tons, respectively.

By adopting a standard collecting unit, hoisting equipment, including cranes, runways and slings; hauling equipment, including wagons and tractors; transporting equipment, including railway and electric cars, steam and tow barges, become standards for loading and disposal stations for various wastes.

The studies so far conducted indicate that it may be considered an axiom that that system handling an offensive substance which exposes the least or fewest surfaces to contact with such substance is the most sanitary, least offensive and, in general, commercially the best.

TABLE 1 COST OF GARBAGE DISPOSAL IN CHICAGO FOR FIVE YEARS PREVIOUS TO ACQUISITION OF GARBAGE PLANT BY THE CITY

Year Ended September 30	Amount Paid by City	Number of Tons Delivered	Cost Per Ton
1909	$47,500	89,957	$0.528
1910	47,500	97,087	0.489
1911	47,500	115,364	0.411
1912	47,500	118,225	0.401
1913	47,500	144,343	0.329
Totals.....	$237,500	564,976	$0.420

TABLE 2 AVERAGE NET COST PER TON TO THE CITY OF CHICAGO FOR HANDLING GARBAGE AT THE MUNICIPAL GARBAGE PLANT FROM TIME OF ACQUISITION TO SEPTEMBER 30, 1916

Year	Expense of Operation	Revenue	Net Cost of Operation	Garbage Tonnage Received	Net Cost Per Ton
1914.....	$154,684.48	$ 96,585.06	$ 58,099.42	75,599¾	$0.768
1915.....	278,570.35	183,196.83	95,373.52	150,874¾	0.632
1916.....	432,721.86	410,512.28[1]	22,209.58	137,920½	0.161
Totals..	$865,976.69	$690,294.17	$175,682.52	364,395	$0.482

[1] During the year 1916 the extractor plant was in operation but from the first of June, and the mill house was not in full operation until the latter part of June. From January 1 to the time of starting the extractor plant, the city received only $3.27 a ton for commercially dried garbage, which is green garbage dried down to 10 per cent moisture.

The capacity of the old mill house was not sufficient to handle all garbage degreased, necessitating the storage of approximately 14,000 tons on the property north of the plant, thereby greatly increasing the cost of production of tankage.

TABLE 3 ESTIMATED PROFIT IN HANDLING GARBAGE AT THE CHICAGO MUNICIPAL PLANT DURING 1917

Cost of Operation	Revenue[1]	Net Revenue	Garbage Tonnage	Net Profit Per Ton
$477,000	$603,000	$126,000	145,000	$0.869

[1] Price of grease taken at 5 cents per pound and tankage at $5.00 per ton, both figures much below the present market prices.

COST FIGURES ON GARBAGE DISPOSAL

It is entirely feasible to construct a reduction plant or an incinerator to operate in a sanitary and inoffensive manner. To lay down a fixed set of rules, however, is not permissible, as the waste problems of each city must be considered as separate and distinct. Generally it costs money to incinerate, whereas money can be made by reduction, as will be seen from Tables 1 to 3.

SYSTEMS OF GARBAGE REDUCTION

Briefly, the following may be considered the present methods or systems of garbage reduction: Cooking process (Arnold and Edgerton), Cobwell system, chemical process, and drying process (Mertz and Simons).

In the cooking process the raw garbage is fed into large tanks called digesters, holding several tons of garbage each. These tanks are then closed and the contents subjected for several hours directly to a steam pressure varying between 40 and 80 lb. per sq. in., the tendency being to break down the cellular structures by boiling.

When the digestion is completed the emulsion of grease and tank liquors is drawn off. The solid matter generally is fed to a press where the main portion of the entrained oil and liquors is forced out, leaving a tankage containing 40 to 50 per cent of moisture. The tank liquors and grease obtained from the cooking and pressing process are passed through a series of settling tanks or basins in which the grease is separated gravimetrically and drawn off or skimmed from the top.

The tank liquors, which contain considerable fertilizer value, are treated in a multiple-effect evaporator to thicken before mixing with the degreased tankage.

The tankage after pressing is properly dried and subjected in a percolator to the action of a grease solvent which absorbs the remaining grease. The saturated solvent is distilled off and condensed, leaving the grease, the solvent being ready to use again. The degreased tankage and liquor, called "stickwater," are mixed, dried, milled and shipped.

There are several successful reduction plants employing this process, among them being the municipally owned and operated plant of the city of Columbus, Ohio, and privately operated plants at Pittsburgh and Philadelphia.

In the Cobwell system the green garbage is fed into a tub-shaped digester tank of several tons capacity, provided with a steam jacket or interior heating coils, and subjected to the direct action of a grease solvent at a temperature under 200 deg. fahr. Dehydration takes place for several hours, during which time the vapors are drawn off and condensed. These vapors consist principally of moisture and a portion of entrained solvent. After condensation the solvent is separated from the water and is ready for use again, the water generally being wasted.

During this operation a large proportion of the grease is dissolved in the solvent and the cellular structures for the most part broken down. The saturated solvent is then drawn off.

The tankage remaining in the digester is subjected to one or more washings of grease solvent, for the purpose of obtaining the greatest permissible amount of grease. The solvent with the dissolved grease is then drawn off and live steam introduced, as in the case of most percolator processes, to drive off as much of the remaining solvent as possible, to minimize loss. The tankage is then subjected to drying under vacuum by heat supplied from the steam jacket or coils.

When the moisture content has been reduced to less than 10 per cent, the contained tankage is removed, ground, screened and shipped.

It will be noted in this process that a large portion of the reduction is done in the one tank or digester.

Some of the latest municipal installations employ this system, among which are those in New Bedford and Los Angeles. The city of New York is endeavoring to build a plant, equipped with this process, of 2000 tons capacity of green garbage per 24 hours, estimated to cost approximately two drying. The material from the crusher is then fed into dryers, its moisture content being reduced to 10 per cent or less. From the dryers it is fed into percolators where it is subjected to the action of a grease solvent. The grease-saturated solvent is then drawn off and the solvent distilled off and condensed for repeated use, the grease being treated and stored ready for shipment. Steam is then turned on to drive off any residual solvent, after which the tankage, which contains about 26 per cent moisture, is withdrawn and then put through final dryers and dried to about 6 to 8 per cent

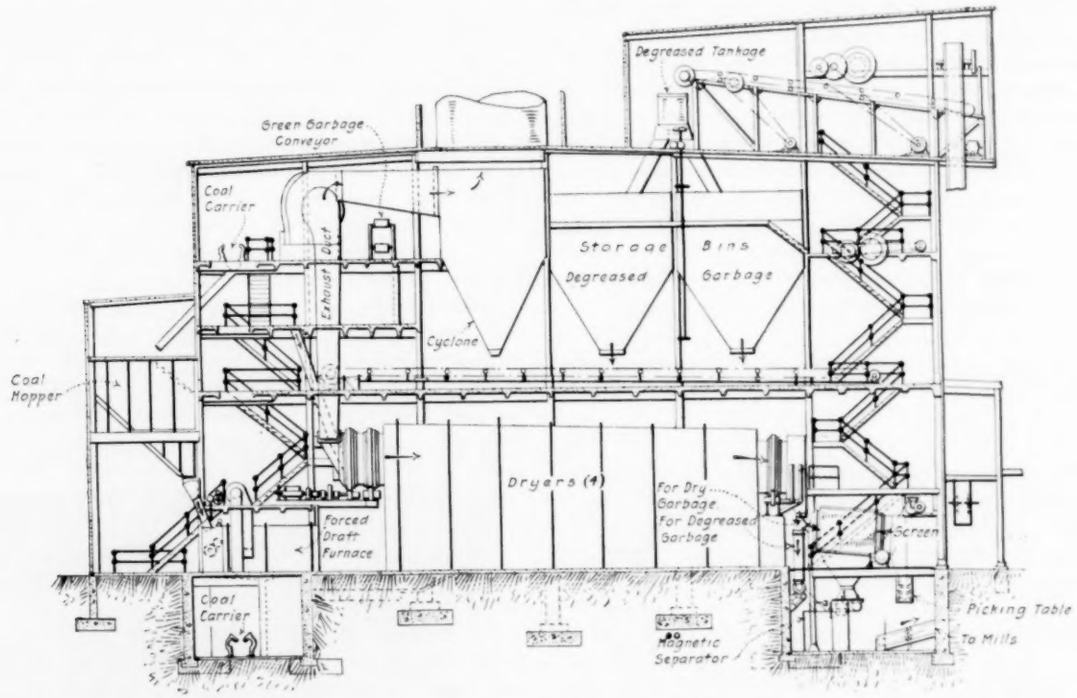


FIG. 3 LONGITUDINAL SECTION OF DRYER BUILDING, CHICAGO MUNICIPAL REDUCTION PLANT

and one-half million dollars. New York is having the common difficulty of securing a suitable location for the plant, owing to the objection of property owners near sites deemed suitable.

The chemical process proposed by Dr. Hirsch has not been demonstrated with the required exactitude to enable competent engineering judgment to be passed upon it. It consists of a treatment tank containing several tons of green garbage, the garbage being subjected to the action of certain chemicals which convert the cellulose into dextrin, or dextrose, depending upon the temperature employed and the time. Personally, I have great hope that such a system may be evolved.

Dr. Morgan claims to have a process by which he produces alcohol directly from garbage. The experiments so far made by him have not yet, I am informed, been sufficiently conclusive to enable an engineering report to be made.

In the three systems above described it will be noted that the green garbage is fed into tanks, which are then closed and the contents exposed to treatment.

GARBAGE-REDUCTION PROCESS USED IN CHICAGO

The fourth process mentioned is the dryer process and is the system in use at the municipal reduction plant in Chicago. In this process the garbage is generally first run through a crusher to smash open cans of condemned foodstuffs and to break up other large material to permit of more efficient moisture. It is then screened, milled and screened and stored ready for shipment.

This system was one of the first employed, but in most cases has been replaced by the cooking process or its latest modification—the Cobwell system. My investigation convinced me that one great cause of offense at the plant of the Chicago Reduction Co. was due to the use of direct-heat dryers and the consequent burning or carbonizing of certain greases and materials such as hair and flesh. This scorching action not only was the cause of offense, but also, I believed, the cause of loss in the amount and value of the by-products. The result was the installation of the more costly direct-indirect-heat dryers.

As predicted, when using the indirect-heat dryers not only has the necessity for scrubbing practically been eliminated, but the tankage and grease produced are better, with consequent increased values. The garbage is dried from 75 per cent moisture to 10 per cent or less in one cylinder.

The principal aim in designing this plant was to eliminate offense; therefore, not being content with the results thus attained, I thought it advisable to provide each dryer with a petticoat stack. This stack permits commingling of outside air with the gases escaping from the dryer, therefore cooling and throwing down a certain amount of moisture (which carries with it considerable very fine suspended matter) and in addition causing dilution.

The stacks are provided with suitable sprays, for use in case of any possible emergency due to delayed collection in hot weather or accidental fire or overloading. It will be noted that each dryer is arranged in the newly designed dryer building as a practically complete unit, having its own cyclone and petticoat stack.

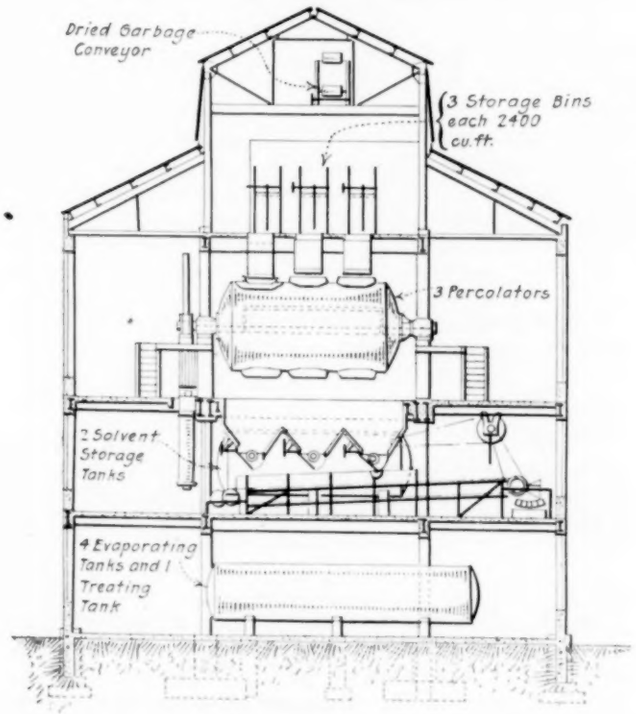

Dried Garbage Conveyor
3 Storage Bins each 2400 cu.ft.
3 Percolators
2 Solvent Storage Tanks
4 Evaporating Tanks and 1 Treating Tank

FIG. 4 CROSS-SECTION OF EXTRACTOR BUILDING

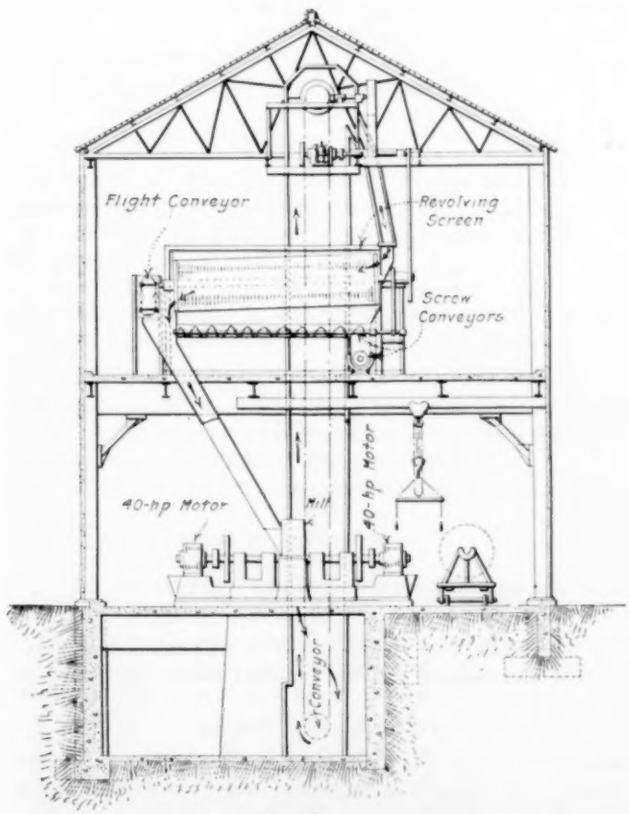


FIG. 5 CROSS-SECTION OF MILL BUILDING

BY-PRODUCTS FROM GARBAGE

An interesting as well as an economically important phase of the garbage-disposal situation are the many products derivable and derived from garbage, as indicated in Table 4. The kind and number of by-products produced, however, are matters to be determined by commercial expediency.

TABLE 4 PRODUCTS DERIVABLE AND DERIVED FROM GARBAGE

Garbage..	Moisture plus Volatile (75%)....	Ethyl alcohol, Methyl alcohol, Formic acid, Acetic acid, Citric acid, Malic acid, Essential oils		
	Solids (25%)..	Garbage Grease	Glycerine.....	Nitroglycerine, Soaps, Toilet articles, Confectionery
			Stearic acid...	Candles, Soaps, Fluxes
			Red oil.....	Automobile industry, Liquoring fat, Sulphonated oil
		Tankage.....	Carbohydrates	Starches, Sugars, Gums, Dextrine, Alcohol
			Proteins.....	Stick Ammonium sulphate
			Inorganic salts	Potassium sulphate and other potassium salts, Acid phosphate, Bone phosphate of lime
			Rags.....	Paper pulp
			Tin cans.....	Tin, Iron scrap
			Miscellaneous.	Glass, crockery, metal (other than tin cans) sand, ashes and rubbish

I estimate the amount of garbage that will be delivered to the plant during the year 1917 at not less than 150,000 tons, from which should be obtained not less than 8,000,000 lb. of grease and 30,000 tons of tankage. The city of Chicago at present has a contract for the purchase of garbage grease at a price of 7.29 cents per lb. on a basis of 3 per cent unsaponifiable, total impurities not to exceed 6 per cent. The city has a contract for the purchase of garbage tankage at the sum of $4.16 per ton. The price received for the grease is high, but that received for tankage is low, the present market value of garbage tankage exceeding $7 per ton.

In the July issue of the *Proceedings of the Engineers' Club of Philadelphia*, D. Robert Yarnall and G. A. Binz review recent development in V-notch weir measurement, concluding with a description of an elaborate test of a standard Lea meter made at the University of Pennsylvania. The paper is abstracted from the proceedings of the meeting of the Philadelphia Section of the Am.Soc.M.E., April 24, 1917.

COMBINED STRESSES

By A. LEWIS JENKINS, CINCINNATI, O.

Member of the Society

In the past few years much has been written regarding the applications of the formulæ for combined stresses. The discussions consist of theoretical and experimental analyses of the stress relations resulting from complexed loadings which produce more than one kind of simple stress, such as combined shear and tension; and most of these are endeavors to prove that the designer should base his calculations on the maximum existing shear stress regardless of the relative strengths of the materials in tension compression and shear.

This popularity and stimulated interest in the subject of combined stresses was induced by Guest, who in 1900 pub-

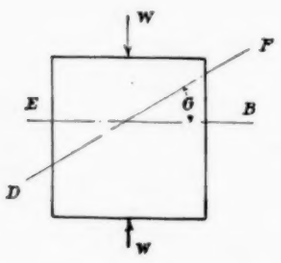


Fig. 1 Bar Subjected to Compressive Load

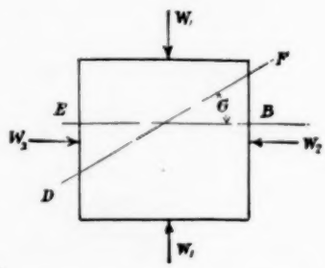


Fig. 2 Bar Subjected to Two Compressive Loads

lished the results of his tests on the strengths of soft steel, copper and brass tubing when subjected to bending and twisting. The main conclusion drawn from the results of these experiments was that they were in accordance with the previously established fact that soft steel and most ductile materials are weaker in shear than in tension. Recently several writers have extensively advocated the use of the maximum-shear-stress hypothesis until they have reached the limit of having suggested its application in the design of cast-iron members! One of the most recent handbooks for designers gives only Guest's formula for the design of shafting subjected to combined bending and twisting, without mentioning the fact that it is absurd to use it for anything but a soft, ductile material.

There are six possible hypotheses upon which a formula for combined normal and shearing stresses may be based, namely, the maximum apparent and the maximum true or equivalent stresses in tension, compression and shear. Of these only the maximum apparent stresses in tension and shear and the equivalent tensile stress have been generally proposed for the design of shafts. Guest's formula is evidently not based on the apparent maximum shear stress as some writers have assumed.

APPARENT AND EQUIVALENT STRESSES DUE TO LOADS THAT PRODUCE SIMPLE TENSION AND COMPRESSION DIRECTLY

Apparent Stresses in Normal and Oblique Planes. The bar shown in Fig. 1 is subjected to a compressive load W, and the simple compressive unit stress on the section EB is $C = W/A$ where A is the area of the cross-section through EB.

Presented at a meeting of the Cincinnati Section of The American Society of Mechanical Engineers, February 15, 1917.

The area of the cross-section through DF, inclined at an angle G with EB, is $A/\cos G$; and the force normal to the plane DF is $W\cos G$; hence the apparent compressive unit stress acting normal to DF is

$$C' = \frac{W\cos G}{A/\cos G} = \frac{W\cos^2 G}{A} = C\cos^2 G$$

The component of W acting parallel to DF is $W\sin G$; hence, the apparent tangential or shear unit stress along DF is

$$S' = \frac{W\sin G}{A/\cos G} = \frac{W\sin G \times \cos G}{A} = \frac{C\sin^2 G}{2}$$

The value of S' is a maximum when $G = 45$ deg., which means that the maximum apparent shear stress is along the plane making 45 deg. with the direction of the load and is equal to

$$S' = \frac{C}{2} = \frac{W}{2A} \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

This indicates that the shear stress in a cast-iron cube is roughly equal to half the compressive stress when failure occurs.

The bar shown in Fig. 2 is subjected to two compressive loads W_1 and W_2 acting at right angles. Denoting the simple

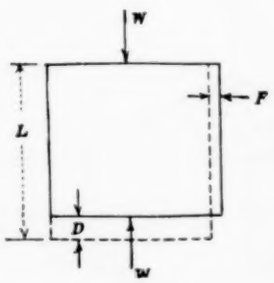


Fig. 3 Deformation of Loaded Bar

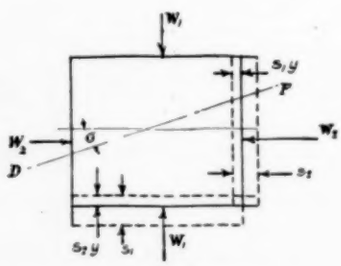


Fig. 4 Direct Compressive Unit Strain on Bar

compresses unit stresses by C_1 and C_2 respectively, the apparent compressive unit stress on the plane DF is equal to

$$C' = C_1\cos^2 G + C_2\sin^2 G \quad \ldots\ldots\ldots\ldots\ldots [2]$$

and the apparent unit shear stress on DF is

$$S' = \frac{C_1}{2}\sin 2G - \frac{C_2}{2}\sin 2G$$

which is a maximum when $G = 45$ deg. and equal to

$$S' = \tfrac{1}{2}(C_1 - C_2) \quad \ldots\ldots\ldots\ldots\ldots [3]$$

If W_1 and W_2 were reversed, they would produce tension instead of compression, and the apparent tensile unit stress on DF would be

$$T' = T_1\cos^2 G + T_2\sin^2 G$$

where $T_1 = W_1/A_1$ and $T_2 = W_2/A_2$. The maximum apparent shearing unit stress is a maximum when $G = 45$ deg. and is equal to

$$S' = \tfrac{1}{2}(T_1 - T_2)$$

If W_1 produced direct compression and W_2 direct tension, the apparent unit stresses would be

$$C' = C_1 \cos^2 G - T_2 \sin^2 G$$
$$T' = T_2 \sin^2 G - C_1 \cos^2 G$$

and the maximum apparent shearing stress is

$$S' = \tfrac{1}{2}(C_1 + T_2).$$

It is seen from equation [2] that the greatest apparent compressive unit stress for the loading shown in Fig. 2 is either $C_1 = W_1/A_1$ or $C_2 = W_2/A_2$, depending upon the relative values of the loads and respective areas, the compressive stress normal to W_1 being independent of the load W_2 or the unit stress C_2.

Equivalent Stresses in Normal and Oblique Planes. The above method of determining the effect of combined stresses employs the ordinary methods of statics, and the results are known as apparent stresses. The method is based on the conception that unit stress is an internal resisting force acting on a unit area, and is found by dividing the load by the area.

A better conception of stress assumes that it is that property of a material which resists deformation of strain, and its intensity is measured by the product, Es, where E is the modulus of elasticity and s the unit strain or deformation produced in a unit of length.

In Fig. 3 the load W deforms the bar of unit area an amount equal to D and the unit deformation in the direction of W is $s = D/L$, where L is the length of the bar, and the unit compressive stress is $C = Es$.

Although there is a slight decrease in the volume in this case, due to the load W, the lateral dimension, which is equal to unity, is increased an amount equal to F. The ratio $F/(D/L) = F/s = y$ for a unit block is a constant for a given material, and is known as Poisson's ratio of lateral contraction. For any size block having a lateral dimension in the direction of F equal to L', then $y = (F/L') \div (D/L)$.

In Fig. 4, W_1 produces a direct compressive unit strain in its direction equal to $s_1 = C_1/E$ and a lateral unit strain (extension) equal to $s_1 y$.

The total unit strain in the direction of W_1 is

$$s_1 - s_2 y = \frac{C_1}{E} - \frac{C_2 y}{E}$$

The equivalent stress, or the single simple stress that will produce an equivalent strain in the direction of W_1 equal to that actually produced in that direction by the combined action of W_1 and W_2, is C_{e_1}. Hence

$$\frac{C_{e_1}}{E} = \frac{C_1}{E} - \frac{C_2 y}{E}$$

and $C_{e_1} = C_1 - C_2 y$.

Similarly the equivalent stress in the direction of W_2 is

$$C_{e_2} = C_2 - C_1 y$$

The equivalent compressive stress on the section DF is

$$C_e = C_{e_1} \cos^2 G + C_{e_2} \sin^2 G$$

and the maximum equivalent shear stress is

$$S_e = \tfrac{1}{2}(C_{e_1} - C_{e_2}) = \tfrac{1}{2}(C_{e_1} - C_2 y - C_{e_1} - C_e y) = \frac{1+y}{2}(C_1 - C_2) \quad [4]$$

In general, the equivalent normal stresses (compression and tension), produced by simple compressive and tensile stresses acting in three directions perpendicular to one another, as shown in Fig. 5, are when all are tension,

$$T_{e_1} = T_1 - T_2 y - T_3 y$$
$$T_{e_2} = T_2 - T_1 y - T_3 y$$
$$T_{e_3} = T_3 - T_1 y - T_2 y$$

If any of the stresses should be compression instead of tension, its sign in the above equations should be changed.

The equivalent shearing stresses are:

$S_e = \tfrac{1}{2}(T_{e_1} - T_{e_2})$ in the plane of S_1 and S_2

$S_e = \tfrac{1}{2}(T_{e_2} - T_{e_3})$ in the plane of S_2 and S_3, etc.

MAXIMUM APPARENT AND EQUIVALENT STRESSES DUE TO COMBINED NORMAL AND SHEAR STRESSES

In machine construction many parts are required to resist both a single normal stress (tension or compression) and a simple shear stress. Cases where a machine element is subjected to more than one normal stress, together with one or more shear stresses, are quite rare; but there are many examples of a single normal stress being combined with a single shear stress, as in shafts being subjected to bending and twisting, propeller shafts, webs of beams, girders and machine frames, lathe beds, planer and boring-mill rails, spindles of milling machines, drilling machines and saws, bolts, screws for transmitting power, and numerous other machine parts.

Let the rectangle in Fig. 6 represent a small elementary area subjected to both a simple tensile stress T and a simple shear stress S, such as exists on the tension side of a shaft subjected to bending and twisting or in the web of a beam subjected to bending. On the compression side of a shaft or beam the normal stress is compression, or negative, and is denoted by C as shown in Fig. 7.

The normal stresses T and C may be produced by loads causing tension, compression or by any of their combinations, and

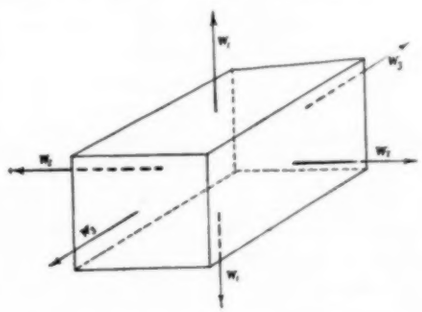


FIG. 5 LOADS IN THREE DIRECTIONS

the shear stress S may be produced by torsion or any other shearing action, such as vertical and horizontal shear in beams.

There are two ways in which the combined effect of these simple stresses may be expressed, namely,

1 By employing the ordinary methods of statics, in which case the results are known as apparent stresses

2 By applying the elastic theory, which states that the stress depends entirely upon the deformation or strain in the body. The results of this method, which is merely a refinement of the other, are called equivalent stresses.

The derivation of the formulæ for finding these stresses may be found in most textbooks on the strength of materials.

Maximum Apparent Normal Stresses. By resolving the stresses T, C and S perpendicular and parallel to any line such as AB in Fig. 6, the apparent shear stress along AB and the apparent compressive stress perpendicular to it may be found. Similarly, the tensile stress on FD may be found. When $\tan 2G = -2S/T$, the normal stresses are a maximum, which gives for the maximum apparent tensile stress

$$T' = \frac{T}{2} + \frac{1}{2}\sqrt{4S^2 + T^2} \quad [5]$$

and for the maximum apparent compressive stress acting at right angles to it

$$C' = \frac{T}{2} - \frac{1}{2}\sqrt{4S^2 + T^2} \quad [6]$$

Similarly, in Fig. 7 the maximum apparent tensile stress is

$$T' = \frac{C}{2} - \frac{1}{2}\sqrt{4S^2 + T^2} \quad [7]$$

and the maximum apparent compressive stress is

$$C' = \frac{C}{2} + \frac{1}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots\ldots\ldots [8]$$

From these equations it is seen that if a body is subjected to both a simple tension and a simple shear stress, the maximum apparent tensile stress is greater than the maximum apparent compressive stress by an amount equal to

$$T' - C' = \sqrt{4S^2 + T^2}.$$

In the case of a circular shaft subjected to bending and twisting, the stresses due to bending are T on the tension side and C on the compression side, and since these are numerically equal, the values of T' and C' are also equal.

Rankine held that the yielding of a material subjected to combined stresses depends entirely upon the maximum apparent normal stress, and was independent of the apparent shear and other stresses which may act at right angles to it. He also made no distinction as to the relative strengths of material in simple tension, compression and shear.

Maximum Apparent Shear Stress. The apparent shear

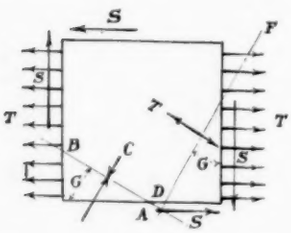


FIG. 6 SMALL ELEMENTARY AREA IN SIMPLE TENSION AND SHEAR

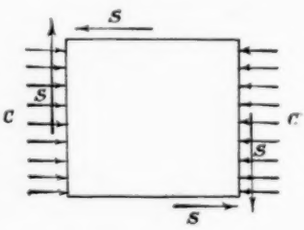


FIG. 7 NORMAL STRESS ON COMPRESSIVE SIDE

stress acting along AB in Fig. 6 becomes a maximum when $\cot G = 2S/T$ and is equal to

$$S' = \tfrac{1}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots\ldots\ldots [9]$$

and for Fig. 7

$$S' = -\tfrac{1}{2}\sqrt{4S^2 + C^2} \quad \ldots\ldots\ldots\ldots\ldots [10]$$

These formulæ have recently become popular on account of some writers having suggested their use in preference to any others, and by so doing they have made the same claims for them as Rankine made for the maximum normal stress formulæ, and again the relative strength of the material has been neglected.

Maximum Equivalent Normal Stresses. Any point on the surface of an area subjected to the simple stresses T and S is acted upon by an apparent tensile and an apparent compressive stress having directions at right angles to each other. In the planes of maximum stress these stresses become T' and C' and they produce a deformation or strain equal to

$$\frac{T'}{E} - \frac{C'y}{E}$$

The equivalent stress, namely, that single tensile stress which would produce a deformation equal to that actually produced by T' and C' is

$$T_e = T' - C'y$$

and the equivalent compressive stress is

$$C_e = C' - T'y$$

By substituting the values of T' and C',

$$T_e = \frac{1-y}{2}T + \frac{1+y}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots [11]$$

and

$$C_e = \frac{1-y}{2}T - \frac{1+y}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots [12]$$

In Fig. 7 the equivalent tensile stress is

$$T_e = \frac{1-y}{2}C - \frac{1+y}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots [13]$$

and the equivalent compressive stress is

$$C_e = \frac{1-y}{2}C + \frac{1+y}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots [14]$$

It should be noted that according to equation [11], $T_e = (1+y)S$ when $T = 0$; and $T_e = T$ when $S = 0$.

The theory that these equations should be applied to problems in combined stresses is due to Saint Venant, and is based on the assumption that the yield point of a material does not depend upon the apparent stress or stresses in any given direction, but upon the deformation or strain. It is sometimes known as the "maximum strain theory." This theory also neglects the relative strengths of the material.

Equivalent Shear Stress. The equivalent shear stress is

$$S_e = \frac{1}{2}(T_e - C_e)$$

and by substituting for the case shown in Fig. 6, gives

$$S_e = \frac{1+y}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots\ldots\ldots [15]$$

and for Fig. 7,

$$S_e = -\frac{1+y}{2}\sqrt{4S^2 + C^2} \quad \ldots\ldots\ldots\ldots\ldots [16]$$

In equation [15] it should be noted that $S_e = (1+y)S$ when $T = 0$; and $S_e = \frac{(1+y)}{2}T$ when $S = 0$.

The quantity $1+y$ is the ratio of the modulus of elasticity in tension to the modulus of elasticity in shear (modulus of rigidity).

This indicates that the true stress in a circular shaft subjected to a torsional moment M_t, is

$$S_e = \frac{5.1\,M_t}{(1+y)D^3}$$

and the true shear produced by a direct or purely tension or compression load is

$$S_e = \frac{(1+y)}{2}T \text{ instead of } \tfrac{1}{2}T$$

and $C_e = \frac{(1+y)C}{2}$ instead of $\frac{1}{2}C$.

Although these formulæ are given in Merriman's Mechanics of Materials in the form $S_e = \frac{(T_e - C_e)}{2}$, they have not been mentioned in the numerous discussions on combined stresses occuring in engineering periodicals.

RELATIVE STRENGTHS OF MATERIALS

Hard or brittle steels and cast iron fail in tension when subjected to torsional load or a tension load, and in shear when subjected to compression. Soft steels and other ductile materials fail in shear when subjected to either a tension or compression load or a torsional moment.

A hard-steel or cast-iron beam of T cross-section will fail in tension even though the flange is on the tension side. It is practically impossible to design a cast-iron beam that will fail on the compression side, and if the facilities for testing the strengths of materials were limited to a bending test, not even a conception of the compressive resistance of cast iron could

be determined. Neither can the shearing strength of a rectangular or a round bar made of brittle steel be determined from a bending test, for the simple reason that the tensile stress reaches the ultimate strength of the material before either the compressive or shear stresses become ultimate.

A torsion test of a round bar is extensively used in determining the shearing strengths of materials because pure torsion produces a shear stress that is greater than the normal stresses. The apparent normal and equivalent stresses produced are at least equal to the shear stress, and if the material is stronger in shear than in tension, it will fail in tension along a helical surface making an angle of about 45 deg. with the surface of the bar. Such a test is by no means a measure of the shearing strength of a brittle material such as cast iron.

When a highly finished soft-steel bar is subjected to tension, a series of lines inclined to the axis at about 45 deg. are readily noticeable after the elastic limit has been reached. These are known as "Lüder's lines," and are in the direction of the maximum shear stress. They indicate that the elastic shearing resistance and not the elastic tensile stress determines the yield point. Soft-steel bars actually fail in shear with a cup-shaped fracture that is somewhat modified by the flow of the metal during contraction.

It is known that brittle materials do not suffer an appreciable lateral contraction before failing in tension. They are stronger in shear than in tension, and the yield point of a hardened-steel bar almost coincides with the ultimate strength, it being elastic under almost any load within its ultimate strength. These facts suggest that the yield point and elastic limit might be wholly dependent upon the shear and not upon the tension- or compression-resisting properties of the material. In the light of the present knowledge of the effect of hardening steels, it is entirely possible that the actual ultimate tensile stress is not increased by hardening and the apparent increase in tensile strength is caused by the increased shearing resistance due to the treatment.

In view of these facts, it seems quite probable that the tension test of a soft-steel bar does not reveal its true tensile strength, yield point or elastic limit with any greater degree of accuracy than a torsion test reveals the shearing strength of hard steel or cast iron. It would be very interesting to know the tensile strength of a bar loaded in such a way as to eliminate the shearing stresses and thereby forcing its failure to occur in tension.

The term *compressive strength* is merely used to denote the unit compressive stress in a body subjected to a compressive load when the shearing stresses and friction can no longer resist rupture.

It is easy to see that a bar may be ruptured in tension by the fractured surfaces separating normally or in shear by the fractured surfaces sliding upon each other, producing tangential separation; but in the case of a short bar of metal or stone subjected to compression, the direct effect of the load is to press the material together instead of producing separation.

Very soft materials, when subjected to compression, flow laterally and do not separate; whereas brittle materials fail in shear before they will flow, and some steels develop cracks parallel to the direction of the load after the material has suffered considerable lateral extension, showing that the separation is caused by tension. It is difficult to acquire an abstract conception of ultimate compressive strength, and no means are available by which even the elastic compressive strength may be shown to be dependent upon any property other than the elastic strength in shear.

SELECTION OF FORMULA FOR A GIVEN MATERIAL AND LOADING.

A body subjected to a complex loading will fail when the stress in any direction at any point reaches the ultimate resistance of the material in that direction at that point.

Conceive of a chain consisting of three or more elements of special design—one link so designed that the maximum stress is tension, another in which the compressive stress is much higher than the tension or shear, and the third element having its minimum resistance in shear. The links are so proportioned that a load on the chain will produce a tension, compression and shear stress in the respective links that is numerically the same for all. How would the chain fail? If made of cast iron it would fail in tension, of glass it would fail in compression, and of soft steel it would fail in shear. It is obviously absurd to say that such a chain constructed of hard steel or cast iron would fail in shear; yet that is in accord with the idea that some discussions on combined stresses were intended to convey.

According to Hancock, the numerical values of the stress at the yield point and at the elastic limit are practically equal. It has also been observed that a material usually fails ultimately in the same manner in which it first yields; hence the yield points or elastic strengths of a material may be used as a criterion of its relative ultimate strengths.

Let Q = yield point in shear
P = yield point in tension
F_s = factor of safety in shear = Q/S_s
F_t = factor of safety in tension = P/T_s

In order to have equal factors of safety against yielding in tension and shear

$$F_t = F_s \text{ and } \frac{F_t}{F_s} = 1$$

substituting,

$$\frac{P/T_s}{Q/S_s} = 1$$

$$\frac{P}{Q} = \frac{T_s}{S_s} = \frac{(1-y)}{(1+y)} \frac{T/S}{\sqrt{(4+T^2/S^2)}} + 1 \quad \ldots\ldots [17]$$

If the right-hand side of this equation is greater than the left the factor of safety in tension is less than the factor of safety in shear, and yielding will occur first in tension; which shows that the equivalent-normal-stress formula should be used. If the left-hand member is the greater, yielding will occur first in shear; showing that the formula for equivalent shear stress should be used.

If the value for Q is obtained by a torsion test it is more accurate to use

$$\frac{P}{Q} = \frac{T_s}{S_s} = \frac{(1-y)}{\sqrt{4+T^2/S^2}} \frac{T/S}{} + 1 + y \quad \ldots\ldots [18]$$

These formulæ are for determining whether a body made of a given material and subjected to a given shear and a given tensile stress is weaker in shear than in tension and enable the designer to select the proper formula.

Similar formulæ may be written for compression and shear or compression and tension.

FORMULAE FOR THE DESIGN OF SHAFTS SUBJECTED TO BENDING AND TWISTING

Let M_b = external bending moment
M_t = external twisting moment
M_{be} = equivalent bending moment which would produce the same normal stress as M_b and M_t

M_{te} = the equivalent twisting moment that would produce the same shear stress as M_b and M_t
I = rectangular moment of inertia
J = polar moment of inertia
c = distance from the neutral axis to the extreme fiber or radius of a round shaft
Z_r = rectangular modulus of section, I/c; for round section $D^3/10.2$
Z_p = polar modulus of section $J/c = 2I/c = D^3/5.1$ for round section
D = diameter of shaft
P = unit tensile stress at yield point
Q = unit shearing stress at yield point
T = working stress in tension
s = working stress in shear.

Then

$$M_b = Tx/c \text{ and } M_t = SJ/c$$

Maximum-Normal-Stress Theory. According to the maximum normal tress theory the stress producing yielding is

$$T' = \frac{T}{2} + \frac{1}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots\ldots [19]$$

By multiplying this equation through by J/c and remembering that $J/c = 2I/c$, it becomes

$$T'I/c = TI/2c + \frac{1}{2}\sqrt{S^2J^2/c^2 + T^2I^2/c^2}$$

by substitution, the equivalent bending moment is

$$M_{be} = \frac{1}{2}(M_b + \sqrt{M_b^2 + M_t^2}) \quad \ldots\ldots\ldots [20]$$

and consequently the stress is

$$T' = \frac{5.1}{D^3}(M_b + \sqrt{M_b^2 + M_t^2}) \quad \ldots\ldots\ldots [21]$$

The form frequently given in text books is due to Rankine, who wrote it in terms of the equivalent twisting moment; namely:

$$M_{te} = M_b + \sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots [22]$$

from which the shearing stress is

$$S' = \frac{5.1}{D^3}(M_b + \sqrt{M_b^2 + M_t^2}) \quad \ldots\ldots\ldots [23]$$

which is the same value as given for the tensile stress above. This is due to the substitution of M_{te} for $T'J/c$ in the derivation of the latter formula. If the tensile stress at the yield point due to bending is the same as shearing stress at the yield point due to torsion, T' might be substituted for S'; but as a matter of fact, the ratio P/Q is not unity. The requirement for equal factors of safety in shear and in tension was found to be $T' = PS'/Q$. Hence, Rankine's equation should be written

$$M_{te} = \frac{Q}{2P}(M_b + \sqrt{M_b^2 M_t^2}) \quad \ldots\ldots\ldots [24]$$

for the general case.

Maximum-Strain or Maximum-Equivalent-Normal-Stress Theory. According to Saint Venant's theory the stress producing yielding is

$$T_e = \frac{(1-y)}{2}T + \frac{(1+y)}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots\ldots [25]$$

By the same method used in the preceding case it is found that

$$M_{be} = \frac{(1-y)}{2}M_b + \frac{(1+y)}{2}\sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots [26]$$

and

$$M_{te} = \frac{Q}{P}\left[(1-y)M_b + (1+y)\sqrt{M_b^2 + M_t^2}\right] \quad \ldots\ldots\ldots [27]$$

The formula used by the French engineers is

$$M_{be} = 0.375\,M_b + 0.625\sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots\ldots [28]$$

and was derived by Grashof, who used 0.25 for the value of y.

The formula due to Bach and much used in Germany is

$$M_{be} = 0.35\,M_b + 0.65\sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots\ldots [29]$$

the value of y being taken equal to 0.3.

Maximum-Apparent-Shear-Stress Theory. It has been shown that the maximum apparent shear stress is

$$S' = \frac{1}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots\ldots [30]$$

By multiplying through by J/c and substituting, it is found that

$$M_{te} = \sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots\ldots [31]$$

and

$$M_{be} = \frac{P}{2Q}\sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots\ldots [32]$$

Equivalent-Shear-Stress Theory. From the equation for equivalent shear stress

$$S_e = \frac{(1+y)}{2}\sqrt{4S^2 + T^2} \quad \ldots\ldots\ldots [33]$$

The equivalent twisting and bending moments are

$$M_{te} = (1+y)\sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots\ldots [34]$$

and

$$M_{be} = \frac{P}{2Q}(1+y)\sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots\ldots [35]$$

Maximum Compressive Strength. The fact that practically all materials used in machine construction are equally as strong or stronger in compression than in shear or tension eliminates the compressive strength as a criterion in design. Glass has the distinction of having a greater resistance in tension than in compression and if its physical properties were definitely known it is quite probable that the maximum-compressive-stress theory would be found applicable.

Guest's Formula. The formula deduced by Guest from his experiments is written

$$M_{be} = \sqrt{M_b^2 + M_t^2} \quad \ldots\ldots\ldots\ldots [36]$$

whereas the maximum apparent shear stress gives

$$M_{te} = \sqrt{N_b^2 + N_t^2}.$$

In order to determine the diameter of shaft the former is equated with $TD^3/32$ and the latter with $5D^3/16$, which causes Guest's formula to give a stress twice that of the maximum, apparent-shear-stress formula.

The expression given by Guest could be obtained from equation [32] if $P/Q = 2$ or from equation [35] when

$$P\frac{(1+y)}{2Q} = 1$$

By assuming $y = 0.3$ this expression reduces to $P/Q = 1.57$.

Guest did not give the values of P/Q and y for the materials used in his experiments. The values of P/Q given by Hancock[1] are as follows:

	P	Q	P/Q
Steel Tubing	21,000	10,500	2.000
Nickel Steel	76,500	38,000	2.013
Mild Carbon Steel	47,000	30,500	1.546
Steel (Scoble)	64,600	29,170	2.214
Carbon Steel	55,500	24,400	1.454
Rivet Steel	38,900	23,400	1.662
Nickel Steel	56,000	35,000	1.555
Steel Tubing	17,000	11,500	1.478
Steel Tubing	28,000	16,000	1.750
Steel Tubing	20,000	12,000	1.666

[1] Proceedings A.S.T.M., Vol. viii, 1908.

It is seen from the results in this table that the value of $P/Q = 1.54$ corresponds to that given for mild carbon steel; and the values for steel tubing, the material used by Guest, vary from 1.47 to 2.00. These results apparently favor the two shearing-stress theories about equally well; but by accepting the elastic theory it is preferable to assume that the value 1.54 is the proper one to use, which means that the equivalent-shear-stress theory is the more accurate of the two and should be used for soft or ductile materials. There is nothing in Guest's results to show which of these theories he used. His formula is empirical and the data on the elastic limits and ratios of lateral contraction are lacking.

Selection of Formula. For the design of shafts made of hard or brittle materials such as cast iron or hard steel the Grashof formula

$$M_{te} = \frac{3M_b}{8} + \frac{5}{8}\sqrt{M_b^2 + M_t^2}$$

should be used.

For the design of shafts made of soft or ductile materials such as very mild steels the equivalent-shear-stress formula

$$M_{te} = (1+y)\sqrt{M_b^2 + M_t^2} = 1.3\sqrt{M_b^2 + M_t^2}$$

should be used.

When the equation

$$\frac{P}{Q} = \frac{(1-y)M_b}{(1+y)\sqrt{M_b^2 + M_t^2}} + 1$$

is satisfied both of the above equations give the same result and either may be used. When the right-hand side of the equation is the greater, use the equivalent-normal-stress formula, and when less use the equivalent-shear-stress formula.

CONCLUSION

The equivalent stresses are a refinement over the apparent stresses and both theoretical and experimental results show that the former is the more accurate. The equivalent-stress formulæ are written as follows:

Equivalent tensile stresses

$$T_e = \frac{(1-y)}{2}T + \frac{(1+y)}{2}\sqrt{4S^2 + T^2}$$

$$T_e = \frac{(1-y)}{2}C - \frac{(1+y)}{2}\sqrt{4S^2 + C^2}$$

Equivalent compressive stresses are

$$C_e = \frac{(1-y)}{2}C + \frac{(1+y)}{2}\sqrt{4S^2 + C^2}$$

$$C_e = \frac{(1-y)}{2}T - \frac{(1+y)}{2}\sqrt{4S^2 + T^2}$$

Equivalent shear stresses are

$$S_e = \frac{(1+y)}{2}\sqrt{4S^2 + T^2}$$

$$S_e = \frac{(1+y)}{2}\sqrt{4S^2 + C^2}$$

The tensile-stress formulae should be used when P/Q is less; and the shear-stress formulae should be used when P/Q is greater than

$$\frac{(1-y)T}{(1+y)\sqrt{4S^2 + T^2}} + 1$$

if the material fails in torsion with a helical-shaped fracture, the equivalent-normal-stress formula should be used, and if in torsion it fails in a plane perpendicular to the axis, the equivalent-shear-stress formula should be used.

If a material fails in tension with a decided cup-shaped fracture, the equivalent-shear-stress formula should be used; whereas failure perpendicular to the axis of the tension specimen indicates that the equivalent-normal-stress formula is preferable.

The Association of Iron and Steel Electrical Engineers will hold its eleventh annual convention at Philadelphia, Pa., Sept. 10-14, with headquarters at the Bellevue-Stratford Hotel. The day of Sept. 12 will be devoted entirely to a patriotic program, with addresses by army and navy engineers on vital subjects concerning our industries.

At Harvard University three prizes, amounting to $200, known as The Nelson Prizes in Plumbing, have just been awarded for the best papers on subjects having to do with the theory or practice of plumbing. A new contest similar to the one just completed but involving a larger sum of money is planned, to be offered this coming year. It is probable that a fellowship will be also offered by Harvard, and engineering graduates who have knowledge and ability to handle problems dealing with sanitation should be especially interested.

The annual convention of the American Institute of Electrical Engineers, which was to have been held at Hot Springs, Va., was postponed on account of many conditions arising from the war, and in its place a special two-day convention was held in the Engineering Societies Building, June 27 and 28.

Topics of the professional sessions included high-tension cables, high-tension insulators, use of electricity in mines, and economical combinations of water-power and steam plants. A paper on the last subject described a method for determining the economical limits in steam and water-power developments.

In his presidential address, President H. W. Buck pointed out that, although engineering has been one of the most important factors in the development of our civilization, nevertheless the engineer has had a difficult struggle to begin to attain the recognition due him. However, the particular training that the engineer acquires in the pursuit of his profession particularly fits him to fill every position in our political and economical affairs, and in the future he is destined to occupy more and more positions of public trust.

Mr. E. W. Rice, Jr., president-elect for the coming year, addressed the meeting on Modern Warfare a Question of Engineering. He said in substance that although it is important that we have an army at the front, the most effective work can be done in the shop and office at home by bending forth every effort toward supplying the army with all the modern appliances of warfare to make it most efficient, and not to wait for the miracle that will never appear. He expressed his belief that the submarine problem will be solved by the combined efforts of engineers and scientists, that we should build ships and the best kind of ships, and that all shipping should be used to the best advantage; that it is not so much a question of the number of ships as it is a case of keeping them in use, which means that our docks must be equipped by the most modern apparatus for loading and unloading the vessels so as to keep them in service.

C. O. Mailloux announced that recruiting for a corps of electrical engineers and electrical workers to go to France would soon begin, to build up the electrical systems in that country. This corps will be similar to the body of railway engineers that was recently organized in this country to build up the transportation systems in France.

CONTRIBUTED DISCUSSIONS OF SPRING MEETING PAPERS

SUBSEQUENT to the publication of the account of the Spring Meeting in the July issue of THE JOURNAL, five contributions have been received which should be appended to this account. Prof. R. Poliakoff, of the Technical Institute of Moscow, Russia, contributes a statement of the Technical Bureau of the Russian Artillery Commission in discussion of Mr. E. T. Walsh's paper on The Importance of Intelligent Inspection in Munitions Manufacture; also a more complete discussion of Mr. A. L. De Leeuw's paper on A Foundation for Machine Tool Design and Construction. Mr. Victor B. Phillips, author of the paper on Relation of Efficiency to Capacity in the Boiler Room, now in active service, forwards the closure to the discussion of his paper. Mr. Charles Meier replies to Mr. Carl G. Barth's discussion of his paper on Metal Planers and Methods of Production, and Mr. Barth answers Mr. Meier's reply.

DISCUSSION OF PAPER ON A FOUNDATION FOR MACHINE TOOL DESIGN AND CONSTRUCTION

TO THE EDITOR:

In Par. 32 of his paper, Mr. De Leeuw refers to a tool which he shows in his Fig. 4, mentioning that this tool broke down very soon after the surface of the hollow began to show scratches. I do not know what was the plan of the tool, whether it had a round edge or not, but the scratches might have been attributed to the following reason:

If you take the ordinary round-edge tool (Fig. 1) with the ordinary angles of front rake, side rake and clearance, you will find by a very simple mathematical analysis that when the front rake is less than the side rake—as it usually is—the cutting angle changes from point to point of the edge. I assume herewith that the chip and all its elements go off the bar at a right angle to the cutting edge at the respective point. It will have one value at the plane *ab* (i.e., at the plane of the front rake), a lesser value at the plane *bc* (side rake), and intermediate values at points *de*, etc.; and if you lay off the respective values of the cutting angles at the corresponding different points *a, d, e, c,* of the cutting edge, then these values would change like the curve *a', d', m', c'* (Fig. 2). In other words, the angles will first decrease, then go up a little, then decrease again until they reach the lesser value *cc'*, corresponding to the plane *bc*. These angles, with an ordinary round-edge tool and the ordinary usually accepted angles of side and front rake, therefore change in a curve with some peak points in it.

If you will assume that the chip consists of elementary chips, each element going off the bar at right angles to the cutting edge, then these different elementary chips have to descend on inclined planes with changing angles, and necessarily one elementary chip is either retarded or accelerated in its downward movement by its adjoining chip; and this retardation or acceleration necessarily must create inner friction and cause the different scratches on the hollow of the tool, every single scratch being the mark left by the elementary chip.

If the scratch to which Mr. De Leeuw referred can be attributed to the reasons just cited, then, in my judgment, the following remedy could be suggested to avoid these scratches and prolong the life of the tool:

All the cutting angles must be equal at all points of the cutting edge, starting at the *ab* plane and terminating at the plane *bc;* and in order to achieve this end, the quadrant *adec* should not be a plane but a quadrant of a circle drilled out by a drill with its center point at *b* and having a radius *ab* equal to *bc* and its cylindrical body projecting in the line *adc*. In this way all the cutting angles would be equal all the way through from *a* to *c* just as in the case of a straight-edge tool.

Of course, this calls for another way of preparing the turning tool altogether, both with regard to machining and grinding, but this can be very easily arranged. In fact, I introduced such a tool in the Laboratory of Technology at the Technical Institute, Moscow, Russia, some two and a half years ago, and have also designed some grinding attachments to grind the hollow produced by the drill.

I started to make some experiments with a tool so designed, but had to discontinue them on account of being sent over to this country in connection with the war. I hope, however, to resume the experiments in the near future, and shall be glad to report to your Society the results obtained.

I also made some dynamometer tests with such a tool, but these tests are, too, in an unfinished condition as yet.

Referring to the circular tool of Mr. De Leeuw, Par. 35, I believe that he originated this tool about two and a half years ago. I do not know how much experimenting has been done with this tool in this country, but I may mention that as soon as I read about it in the *American Machinist*, where it was originally described, I prepared a tool along the same lines with the object of making some experiments, but, as already stated, I had to leave for the United States and therefore could not make them.

However, I published an article in a Russian technical magazine describing the construction of this tool, and, based upon this description, a few tools have been prepared in the Ijev Rifle Works, in the Ural mountains. When I visited these works in 1915 I was shown the results of their experiments, which proved to be very satisfactory, both with regard to speed and life of the tool. I have sent these facts to the Russian magazine, *Vestnik Ingenerov,* for publication.

Referring to Mr. De Leeuw's Suggested Lines of Experimentation, I fully agree with what the author says, but I can easily see some objections from the so-called practical viewpoint of shop men. Mr. De Leeuw suggests that these experiments should be made at low speeds, and whatever the results of such experiments should be, the ordinary shop man will probably say, "That's all right—it may be all right in theory, but how about the practical side, where the results of such experiments are quite different?" They will doubt if the results of such experiments can be fully applied to practice.

In connection with this I may mention that very few experimental data have been published along the line of cutting with fine cuts, although a little has been done.

Edward Herbert, of Manchester, England, has been working along such lines for some time, and has invented a special machine for taking very fine cuts from a hollow tube. He has published some of the results of his experiments and they are very interesting, especially with reference to the cut, as they show that a finishing tool fails quite differently from an ordinary roughing tool.

In the roughing cut, when you increase the speed, leaving all other conditions equal, the time of the endurance of the tool decreases, something like curve *ab,* Fig. 3, in which the

abscissæ represent the speed and the ordinates the endurance time. In the case of the finishing tool, however, the endurance curve is something like the curve *abcd*, Fig. 4, with some peaks in it, which means that when you increase the speed of the finishing cut the endurance time may increase up to a certain limit, and then will start to decrease with a further increase in

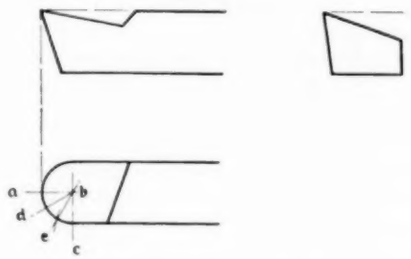


FIG. 1 ROUND-EDGE TOOL

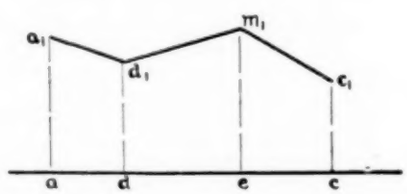


FIG. 2 VALUES OF CUTTING ANGLES

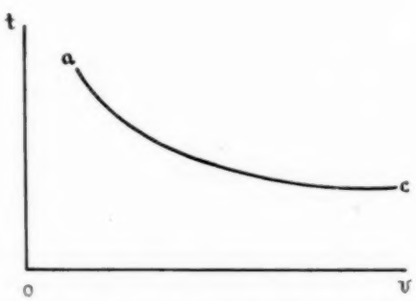


FIG. 3 ENDURANCE TIME OF TOOL IN ROUGHING CUT

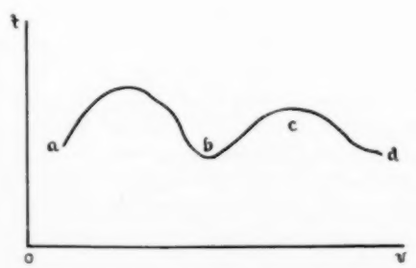


FIG. 4 ENDURANCE TIME OF TOOL IN FINISHING CUT

the cutting speed. If the cutting speed continues to increase, the endurance time may go up again. From this one can draw the conclusion that there is probably a certain speed which is the most profitable for working so far as endurance of the tool (and, as experiments show, also the appearance of the machined surface) is concerned.

When Mr. Herbert presented his paper on this subject some three or four years ago, he met with the same objections to which I have just referred, i.e., that these experiments may be of much theoretical value but are very doubtful so far as practical results are concerned.

In order to meet these objections to a certain extent, I made some experiments on finishing cuts, but in a quite practical way, and under conditions absolutely identical with those prevailing in ordinary shop practice. It would perhaps be out of place to go into too many details of these experiments at this time, especially as I have already presented them in a paper before the Institution of Mechanical Engineers, in Manchester, an extract of which was published in the *American Machinist* some ten months ago.

Suffice it here to say that these practical experiments fully confirmed the results of Mr. Herbert's experiments made under conditions different from shop practice.

Therefore, I can most assuredly say to shop men that practice and theory go hand in hand together, and if the theoretical experiments are conducted on the right lines, they are sure to yield valuable practical results.

R. POLIAKOFF.

New York, N. Y.

AUTHOR'S CLOSURE TO DISCUSSION OF PAPER ON RELATION OF EFFICIENCY TO CAPACITY IN THE BOILER ROOM

TO THE EDITOR:

In their discussions both Mr. Barrus and Mr. Reinicker are unwilling to attach any accuracy to tests of eight hours' duration. The author understands fully the validity of objections to eight-hour tests and the tests in question were conducted with these objections in mind. They could not have been conducted otherwise. As regards the degree of accuracy of the efficiencies obtained, it may be said that the closely accurate determination of efficiency was throughout of secondary importance. None of the data sought nor conclusions reached is impaired by an inaccuracy of, say, 3 per cent in the overall efficiency. The overall efficiency is the only quantity that the employment of the short test can bring into question. It will be noted that differences in efficiency by virtue of differences in fuel-bed thickness are far in excess of any possible inaccuracy in the values of efficiency. Furthermore, all other observations and the conclusions drawn therefrom are in no way subject to the criticism of the short duration. It is quite conceivable that the curvature or slope of some of the lines on the furnace and boiler unit operation charts may be appreciably in error. These charts were presented, however, to illustrate certain general principles, and are believed to be of sufficient accuracy to serve this purpose. The entire part of the paper relating to the boiler as a heat absorber is, of course, not subject to the above criticisms.

The reason for the short tests was the impossibility of operating for a longer period at the heavy overload. It will be noted that the coal used was very high in sulphur. The resultant difficulties with clinker building out from the bridge wall prevented continuing these tests over eight hours. The eight-hour test was adopted for this investigation only after considerable experimentation. It was found that very small changes in the fuel supply could be readily observed in their effect upon the fuel-bed thickness. In considering the accuracy of the tests it must be remembered that firing conditions were kept very constant. Every effort was made to this end. Under such conditions objections to the eight-hour test are minimized. In view of the observed fact that cutting off the fuel supply for five minutes produced an easily observed change in the fuel bed, the author feels justified in claiming

an accuracy in efficiency figures within a 3 per cent limit of variation.

Mr. Spitzglass speaks of the author's failure to study the relation between efficiency and capacity. The author would say here that, assuming the possession of complete data on the operating characteristics of a steam boiler, the study of the above relation must necessarily be a prolonged affair. It involves the loading conditions of the plant, prices of coal and labor, cost of equipment and of land and other conditions affecting power costs. Manifestly it could not be so much as touched upon in the present paper. All that the author hoped to do was to establish the importance of the relation of efficiency to capacity in the boiler as the prime basis of the investigation which has been presented.

Mr. Spitzglass also questions the ability of the fireman "to observe air velocities, draft-gage readings, gas analysis and the flue temperatures," or to interpret such readings. As regards flue-gas analyses, the author fully agrees with Mr. Spitzglass, and takes great pains in the paper to point out how the conditions of combustion may otherwise be easily and simply indicated. As regards the observing of air velocities, the author believes that the air meter, an illustration of which is shown in the paper, may be read as easily as any other form of meter. Concerning the use of instruments in general, the practice of the best plants throughout the country is a sufficient answer. The author heartily subscribes to the value of the steam-flow meter as mentioned by Mr. Spitzglass.

The author wishes to correct the impression that may have been gained that he ever had in mind the use by the fireman of charts such as have been presented in this paper. He would, however, propose the use of scales on the various instruments, having the numbers so arranged as to correspond when operating conditions are proper; e.g., all numbers indicating 5 when No. 5 load is to be carried. Such a system would be readily intelligible to the fireman.

Messrs. Alpern and Reinicker both call into question the matter of air-pressure drops through the tuyeres and fuel bed (i.e., sum of pressure in air boxes of stoker and draft in combustion chamber). Clearly this drop is a function of the amount of air forced through the fuel bed, the areas of air openings in the grates, and the thickness and resistance of the fuel bed. The criticisms seem to assume ability on the part of the operator to regulate this pressure drop independently of load. Such cannot be the case, since any increase in air pressure with a given condition of fuel bed will simply result in a greater combustion rate and will not change proportionately the ratio of air to coal burned. This ratio may be regulated only by regulation of the fuel-bed resistance.

Mr. Alpern speaks of "some operating faults of the tests." The author has nowhere indicated that the air supply to the extension grates was kept continuously at the maximum, nor does Mr. Alpern's discussion indicate to him any faults in operation. The point is that at heavy overloads it is obviously necessary to increase the combustion rates on all parts of the grate surface. This necessity applies to the extension grates as well. The author does not believe that the maximum supply of air to these grates is sufficient for prolonged overloads in the stoker under discussion. Mr. Alpern's statement regarding the relation of air pressures to the different fuel-bed thicknesses is not in accord with the data given in the paper. The author certainly agrees with Mr. Alpern that "the heavy-fuel-bed condition was an unnatural one."

In answer to Mr. Reinicker's statement that the furnace drafts were too high, the author would say that in the particular setting tested, lesser drafts could not be used without driving some gas out of the setting near the top of the first pass and without endangering dump-grate bars. The author fully agrees with Mr. Reinicker as regards the limitations placed upon both capacity and efficiency by high furnace temperatures. Difficulties from clinker and destruction of the refractory lining are perhaps the greatest single barrier operating against heavy overloading. Mr. Reinicker's statement regarding the unimportance of radiation and convection as *losses* and his criticism based thereon have no bearing on the paper under discussion. The author treated radiation and convection as the modes of heat transmission from the furnace to the boiler, and at no point considered their bearing upon the incidental losses from the setting.

In the first paragraph of his discussion, William Kent has put in a few words and in admirable form the idea that has been in the mind of the author for some years, and which led to the preparation of this paper.

VICTOR B. PHILLIPS.

Ft. Leavenworth, Kan.

DISCUSSION OF PAPER ON METAL PLANERS AND METHODS OF PRODUCTION

TO THE EDITOR:

Regarding Mr. Barth's statement in his discussion that the time consumed in stopping and reversing the planer and table must be independent of the length of the stroke and can be considered equal to the time it would take the table to travel an imaginary addition to its actual stroke, I think this is where the misunderstanding comes in. I take it Mr. Barth believes a constant can be found which would be correct for all lengths of strokes. This is impossible owing to the variable quantities governing the different belt conditions; for instance, on long strokes, where the reversals are less frequent, the pulleys do not heat up and the belt slips less than it does on short strokes. It is a positive fact that if a planer is run for any length of time on short strokes (especially with cast-iron pulleys) the belt conditions are continually changing, owing to the slipping of the belts and the heating of the pulleys and the air which seems to get between the belt and the pulley. This condition becomes a great deal more aggravated on short strokes than it does on long strokes, and even at times I have seen it get to a point where the belts would smoke terribly. Anyone who has stood and watched such a performance and observed the variation in the length of stroke will admit that no practical constant can be found which will be correct for all conditions and for all the lengths of strokes.

As to the imaginary length of a perfect stroke, why try to determine on this imaginary quantity when the actual quantity can be so easily figured? Knowing the cutting and return speed and assuming there is no loss at either end, we have the actual ideal condition, which is the theoretical number of strokes I referred to in Table 1.

In making our aluminum pulleys, we aim to get as close to this theoretical or ideal stroke as possible, and just how near we have approached this condition is represented by the efficiency column, from which it can be seen that no one constant can be found to cover all lengths of strokes which would be correct; because what would be correct for the average long strokes would not be correct for the shorter strokes. A graphical diagram, such as is shown in Mr. Barth's Fig. 1, could not be determined, therefore, as the values of a would be variable for different-length strokes.

I cannot see that Mr. Barth's contentions are at all well founded, and I believe if he will carefully analyze the prac-

tical side of these points, he will agree with me that I am correct in what I have said.

CHARLES MEIER.

Cincinnati, Ohio.

TO THE EDITOR:

I appreciate fully what Mr. Meier says in regard to the absurdity of my contentions about a constant imaginary overrun for very short strokes, but as I never allow any planer to run on such absurdly short strokes, it did not occur to me to qualify my statement, as I have now done in correcting my discussion. However, I can assure him that I have too often demonstrated that my contention is correct for all practical purposes, to admit that there is any misunderstanding about this matter, on my part. Besides, the accompanying plot, Fig. 1, of his experiments clearly shows that his shortest stroke did not adversely influence the effective pull of the belt, which, in fact, indicates a higher effective pull on the shortest stroke, both for the cast-iron pulleys and the aluminum, provided any reliance can be placed on his experimental figures in

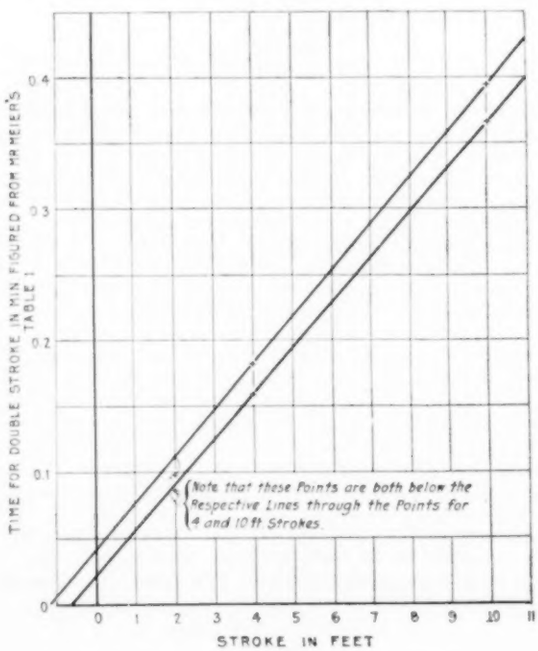

TIME FOR DOUBLE STROKE IN MIN. FIGURED FROM MR MEIER'S TABLE 1
0.4
0.3
0.2
0.1
0
Note that these Points are both below the Respective Lines through the Points for 4 and 10 ft Strokes.
0 1 2 3 4 5 6 7 8 9 10 11
STROKE IN FEET

FIG. 1 PLOT OF MR. MEIER'S EXPERIMENTS

Table 1. I may say, in this connection, that I certainly cannot approve of Mr. Meier's way of figuring the theoretical number of strokes from the theoretical speeds 40 and 90 ft. It savors too much of time studies that give nothing closer than 0.1 min. You can arrive at such matters by indirect methods only.

Regarding the power question, in Par. 11 of his paper, Mr. Meier makes the unqualified statement that the aluminum pulleys show a saving of 25 per cent in power, which, taken by itself, is very misleading, though of course he did not mean it that way. I therefore suggest that he rewrite it something like the following:

"11. Table 2 also shows, what we should expect to find, some reduction in the peak load on the motor during reversal, namely 25 per cent, with the aluminum pulleys as against the cast-iron pulleys.

CARL G. BARTH.

Philadelphia, Pa.

The Society of Industrial Engineers, which was recently organized at Washington, D. C., consists of professional technical engineers, accountants, managing executives in commercial and industrial activities, technical writers, educators and students. It is planned to offer the services of the organization to the Government through Howard E. Coffin, chairman of the Advisory Committee, Council of National Defense, and through such committees as can use the services of industrial engineers. A bureau has been organized under the direction of the president of the society to list all the industrial specialists in the country who may be called upon to serve either as advisers or directors of efficiency work. D. C. Dent, of Chicago, is acting secretary of the organization.

Standard wrought-iron or steel pipe of any size up to and including 10-in. is with three exceptions larger in diameter internally than its specific designation would indicate. Ordinary 1-in. wrought-iron pipe, for example, when made to conform exactly to standard dimensions (which, however, is not always the case) has an internal diameter of 1.05 in., which is 1-20 in. over the nominal size.

On the other hand, extra strong pipe having a higher designation than ½-in. and up to 12-in. is smaller in diameter, with one exception, than the nominal size would indicate. Thus, extra strong 1-in. wrought-iron pipe is 0.95 in. diameter inside, which is 1-20 in. under the nominal size, while double extra strong 1-in. pipe has an actual internal diameter of only 0.60 in., or a little more than half the nominal value.—*Power*, July 17, 1917.

The Shipping Board has announced a call for engineers to serve on the great war fleet that is to be built. It is announced that in the next 18 months no less than 5000 engineers will be needed.

Engineering schools in terms beginning July 21 will be opened at the Massachusetts Institute of Technology, Cambridge, Mass.; at Stevens Institute, Hoboken, N. J.; at the Case School of Applied Science, Cleveland, Ohio; at the Armour Institute of Technology, Chicago, Ill.; at the University of Washington, Seattle, Wash.; and at Tulane University, New Orleans, La.

Each term will last one month, the expense of tutoring being borne by the Shipping Board. The Massachusetts Institute of Technology, it is said, can put through 150 students a month, and other institutions an average of 35 students. Marine engineers of all grades, oilers, water tenders, and stationary engineers are eligible for the classes. (*Christian Science Monitor*, June 23, 1917, p. 3.)

The Chemical News and Journal of Physical Science (vol. 15, no. 3003, June 15, 1917) announces a unique British invention, namely, a secret process for manufacturing rubber sponges.

In making certain rubber goods a "fault" was developed. Its cause was traced and out of it the artificial sponge gradually emerged.

Within the last five years, however, a similar product has been manufactured in America. It appears now that an English inventor, G. W. Leeson, has produced an artificial sponge which is claimed to be superior to those now on the market, as with or without soap it has not the slightest trace of roughness and, in addition, the new sponge retains its freshness for a long time.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in THE JOURNAL, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee as approved by the Council on June 21, 1917, in Cases Nos. 150, 153-157 and 159-161 inclusive. In this report, as previously, the names of inquirers have been omitted.

CASE NO. 150 (REOPENED)

Inquiry: Is it permissible under the rules of the Boiler Code to brace that portion of the head of an h.r.t. boiler below the tubes with diagonal braces, or must this portion of a boiler be braced with through stays?

Reply: Diagonal bracing is not permissible for that portion of the front head of an h.r.t. boiler which comes below the tubes, under Par. 218 of the Code, but it is permissible for the corresponding portion of the rear head.

CASE NO. 153

Inquiry: Does the crowfoot brace illustrated in Fig. 7 meet with the requirements of Par. 223 and Table 4 of the Boiler Code?

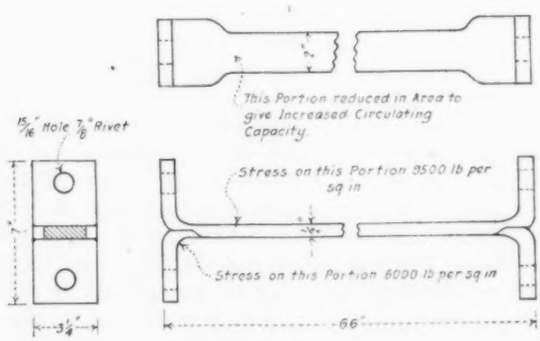

This Portion reduced in Area to give Increased Circulating Capacity
15/16" Hole 7/8" Rivet
Stress on this Portion 9500 lb per sq in
Stress on this Portion 6000 lb per sq in
3 1/4"
66"

FIG. 7 PROPOSED SIDE BRACE FOR 150 LB. W. P.

Reply: The strength of each branch of the crowfoot in the design shown is difficult to compute. As the crowfeet vary so widely on different braces, it was the idea of the Boiler Code Committee in formulating this rule that the manufacturer would test each type of brace made to determine whether it meets the requirements or not, and the Committee suggests that the braces be tested to determine the relative strength of the body of the brace and of a crowfoot. According to the rule, the foot of the brace should be one-third stronger than the body of the brace. It, therefore, follows that if a test brace is made with the body one-third stronger than the brace to be used, the crowfoot of this test brace should be as strong as the body of the brace.

CASE NO. 154

Inquiry: In the staying of a segment of a head, above the tubes, of an h.r.t. boiler in which a manhole is inserted, is there an allowance of 100 sq. in. under the rules of the Boiler Code, as is allowed by Par. 218 for manholes inserted in heads below the tubes?

Reply: Where a manhole is placed above the tubes in an h.r.t. boiler, no allowance shall be made as for the head surface that need not be braced, and the bracing of the head with such manhole opening should conform to that which would be used provided there was no manhole.

CASE NO. 155

Inquiry: What is the application of the rules in Part I, Section 2, of the Boiler Code to the workmanship on steel plate heating boilers? Are punched rivet holes permissible, and also may cast iron mud rings and door frame rings be used?

Reply: The Code does not require the drilling of rivet holes for boilers for low pressure heating or hot water supply, except those that come under the power boiler rules as specified in Par. 335. This also applies for cast iron mud rings and door frame rings, where used.

CASE NO. 156

Inquiry: *a* Will brass or bronze valves and fittings with flange ends in accord with the "1914 Brass Standard Flange Dimensions," when bolted to ferrous fittings as prescribed in Code Tables 15 and 16, comply with the purpose and intent of the Boiler Code Committee's reply in Case No. 101?

b Does the Boiler Code Committee approve the recommendation that the raised face be removed from a Table 16 fitting when it is bolted to a brass or bronze fitting?

c Does the Boiler Code Committee approve the recommendation that full face gaskets be used in a non-ferrous to non-ferrous or a non-ferrous to ferrous flange joint?

Reply: *a* The standardization of bronze fittings has been referred to a special committee of the Society. Until a report upon such standards is prepared and accepted by the Society, the Boiler Code Committee will abide by the decision in Case No. 101.

b All dimensions shall conform to the American Standard given in Tables 15 and 16 of the Appendix for the pressures therein specified, except that the face of the fitting to which it is attached shall be flat and without the raised face where brass or bronze composition fittings are used.

c It is the opinion of the Committee that full face gaskets should be used.

CASE NO. 157

Inquiry: *a* Will cast iron, dove-tail lugs be permissible under Pars. 323 and 324 of the Boiler Code?

b In empire and economic type boilers, where the pads on the cross braces form a reinforcement to the side sheets, what coefficient should be used under Par. 199 of the Boiler Code?

c A ruling is desired covering Par. 254 of the Boiler Code, if no burrs are present.

Reply: *a* This inquiry is answered by Case No. 151.

b According to Par. 203, the value of C to be used should be 135.

c It is the opinion of the Boiler Code Committee that the plates should be separated to make sure there are no burrs.

CASE NO. 158

(In the hands of the Committee)

CASE NO. 159

Inquiry: If the material of which a dished head is formed is thicker than necessary under the rules of the Boiler Code

to sustain the pressure carried, is it necessary to flange a manhole opening, if inserted, to a depth of three times the thickness of the material used?

Reply: The intent of Par. 198 of the Code is that a manhole opening in a dished head shall be flanged to a depth of not less than three times the required thickness of the head, measured from the outside. If, therefore, the required thickness of material for a head is ½ in., the opening needs to be flanged to a depth of not less than 1½ in.

CASE NO. 160

Inquiry: Does Par. 316 of the Boiler Code allow the feed inlet to be located 3 in. from the bottom tube sheet of a small, vertical laundry boiler?

Reply: The Committee has decided that the requirement of Par. 316 does not apply to a small laundry boiler of the type you describe.

CASE NO. 161

Inquiry: Does Par. 218 of the Boiler Code prohibit the hexagonal or beehive arrangement of tubes used in the design of h.r.t. boiler shown in Fig. 8? The reply in Case No. 142

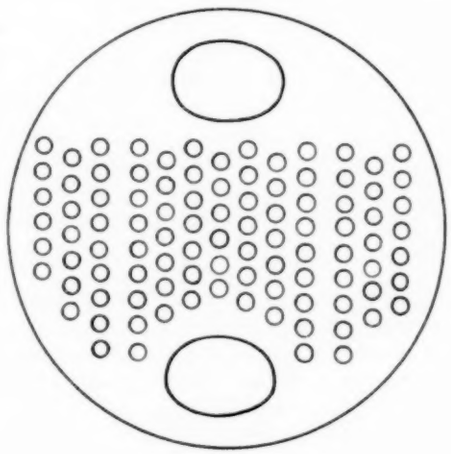


FIG. 8. HEXAGONAL ARRANGEMENT OF TUBES IN H.R.T. BOILER

is taken to apply to the usual tube layout, and does not seem to apply to the special tube layout, there shown.

Reply: The reply in Case No. 142 applies irrespective of the tube arrangement in an h.r.t. boiler.

Revision of Boiler Code

THE Council of the Society has directed that the proposed changes in the Boiler Code be published in THE JOURNAL, with the request that any desired discussion on the proposed changes be mailed to the Boiler Code Committee for consideration. These proposed changes embody suggestions made at the meetings held at the Society headquarters, December 8 and 9, 1916, which were widely advertised as public meetings to which all those interested were invited to attend and participate in the discussions. Publishing the proposed changes will make it possible for any one to discuss the revisions before they are brought to the final form and presented to the Council of the Society for approval. All suggestions will be gratefully received and will be carefully considered by the entire Committee, and a full and free discussion is solicited.

A number of proposed revisions were published in the June issue of THE JOURNAL. There are other revisions which will be published later on with the request that they also be discussed.

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PAR. 29*a*. CHANGE PAR. 29*a* TO READ AS FOLLOWS:

29 *Modifications in Elongation.* *a* For material over 11/16 in. in thickness, a deduction shall be made from the percentage of elongation in Par. 28*a* of four times the thickness in inches in excess of 11/16 in. to a minimum of 20 per cent.

PAR. 30*a*. CHANGE PAR. 30*a* TO READ AS FOLLOWS:

30*a* Tension test specimens shall be taken longitudinally from the bottom of the finished rolled material, and bend test specimens shall be taken transversely from the middle of the top of the finished rolled material. The longitudinal test specimen shall be taken in the direction of the longitudinal axis of the ingot, and the transverse test specimen at right angles to that axis.[1]

PAR. 30*b*. CHANGE PAR. 30*b* TO READ AS FOLLOWS:

30*b* The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

PAGE 13

PAR. 33*a*. CHANGE PAR. 33*a* TO READ AS FOLLOWS:

33*a* *Number of Tests.* One tension and one bend test shall be made from each plate as rolled.

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PAR. 335. CHANGE HEADING WHICH NOW READS "BOILER MATERIALS" TO "GENERAL."

A New Size of Boiler Stamp

WHEN the A.S.M.E. Boiler Code was first issued early in 1915, stencil stamps conforming with the requirements of Par. 332 were prepared by the Society and offered to the public. The stamps were made ¾ in. in diameter and conformed generally with the exterior proportions of the Society emblem. They were widely distributed among boiler manufacturers and are now in extensive use in all parts of the country, seventy stamps in all having been issued up to the present time under the Boiler Code Committee's supervision.

In using a stamp of this size on plates ¼ in. thick or less, the rebound made it difficult to obtain a legible impression unless great skill was used in the stamping process. As a result of this difficulty, an inquiry concerning the matter was placed before the Committee. It was considered as Case No. 139 at the March 16 meeting, and treated as follows:

CASE NO. 139

Inquiry: Is it possible to secure a smaller A.S.M.E. boiler stamp than the present ¾-in. stamp that is furnished to meet the requirements of Par. 332 of the Boiler Code? It is difficult to stamp thin plates with the present ¾-in. stamp on account of the rebound.

Reply: A new stamp will be provided, ½-in. size, hammer

[1] Exceptions made for tension test specimens for plate which is rolled longitudinally with reference to position when used in a boiler shell. See Par. 190.

type, and with the top end square, so that it can be either used as a hammer stamp or struck with a sledge.

The Boiler Code Committee desires to announce that a new stamp is now offered in the form of a hammer stamp, with the size of emblem reduced to ½ in., as illustrated in Fig. 1. The reduced size of the emblem will greatly facilitate the stamping of thin plates, and where desired the impression may be ob-

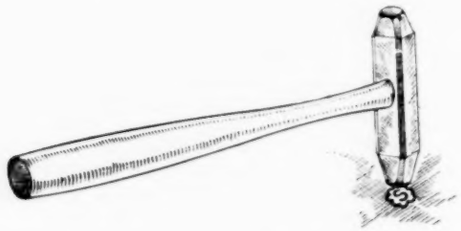

FIG. 3 HAMMER STAMP FOR A.S.M.E. STANDARD BOILERS

tained by using the stamp as a hammer instead of as a sledge in the usual manner.

Manufacturers desiring stamps are reminded that applications either for new or old size stamps must be accompanied by an affidavit made out on the form provided by the Committee and properly executed according to the following resolution approved by the Council:

It is the opinion of the Committee that the official symbol or stamp is to be used to indicate that The American Society of Mechanical Engineers' rules have been compiled with in the construction of the boiler. The stamp shall be affixed by the manufacturer. Certification to be governed by law or contract.

The blank affidavit form may be obtained upon application to the Boiler Code Committee at the Society headquarters.

In an effort to coöperate in the solution of various problems of vital importance to the development of the French industries, the French Society of Civil Engineers decided to organize a Congress of Civil Engineering, which, in its idea, would constitute, something like General Assizes of the Industry for the study of a program to be carried out after the war.

According to a preliminary announcement, the work of this congress will be divided into two groups and several sections.

The first group, embracing Sections 1 to 7, will be of a technical character and will be devoted to the following specialties: Section 1, public works and civil constructions; Section 2, transportation; Section 3, mechanical engineering, motors and machine tools; Section 4, mining and metallurgy; Section 5, industrial physics and chemistry; Section 6, industrial applications of electricity; Section 7, farm engineering and agricultural industries.

The second group, comprising three sections, will be devoted to economic problems and divided as follows: Section 8, rational organization of industrial works; Section 9, social hygiene, accident prevention, healthful work; Section 10, industrial legislation.

It is expected that the first part of the congress, i. e., the National Congress, will be held next November and will be opened to all interested in the economic and industrial future of France. The terms of admission have not yet been announced.

As regards the Inter-Allied Congress, for many reasons it is not expected that it can be organized until after the termination of the war. (Announcement in *Le Génie Civil*, vol. 70, no. 23, June 9, 1917, p. 373)

Tests of aeroplane engines will be made at a laboratory at the Bureau of Standards. At a recent meeting of a subcommittee on power plants of the National Advisory Committee for Aeronautics preparations were made for the development at the Bureau of Standards of a laboratory for testing aircraft engines under conditions of altitude and temperature similar to those encountered in flights at an altitude of 20,000 ft. or more. The laboratory and its experimental equipment will be organized under the auspices of the Advisory Committee, and the investigations will be directed by the subcommittee on power plants. (*The Automobile and Automotive Industries*, vol. 37, no. 2, July 12, 1917, p. 82)

The Autogenous Welding Committee of the American Society of Refrigerating Engineers has been appointed and consists of the following members: F. L. Fairbanks, Mem.Am.Soc.M.E., chairman; Llewellyn Williams, Mem.Am.Soc.M.E.; S. F. Jeter, Mem.Am.Soc.M.E.; P. A. E. Armstrong, metallurgical engineer, the North American Co.; Charles H. Bromley, associate editor *Power;* James C. McCabe, Mem.Am.Soc.M.E.; Theo. Vilter, president Vilter Manufacturing Co., Milwaukee, Wis.; Prof. Edward F. Miller, Mem.Am.Soc.M.E.; John E. Starr, Mem.Am.Soc.M.E., and Thomas Anderson, refrigerating inspector, City of Chicago.

The purpose of the committee is to assist in the development of the welding art and to make its application to pressure vessels as safe as the best knowledge of the subject can make it.

The government of the Union of South Africa has appointed an advisory board to deal with the development of the natural resources of the country. A special scientific and technical committee has been appointed to carry out scientific investigations. This committee consists of Mr. J. Burtt-Davy (botany and agriculture); Mr. L. Colquhoun (chemistry); Professor Young (geology); Professor John Orr, Mem.Am.Soc.M.E. (mechanical engineering); Mr. Bernard Price (electrical engineering); Professor Beattie (physics); Dr. Caldecott (metallurgy); Professor van der Riet (chemistry); Professor Malherbe (chemistry); Dr. L. Peringuey (president of the Royal Society of South Africa). The first step taken by the new committee has been to arrange for the preparation of fifty-two reports by leading experts, dealing with the available raw materials of South Africa suitable for manufacture or export. It is intended that these reports shall be published for the guidance of intending manufacturers and other business men.

In reply to a query from E. P. V. Ritter, of the Merchants and Manufacturers' Exchange, New York City, asking about the advisability of holding conventions during the war, the President has sent the following letter:

"In reply to your letter of June 4, allow me to say that I not only see no reason why commercial conventions should be omitted during the war, but should regret to see any instrumentality neglected which has proved serviceable in stimulating business and facilitating its processes. This is not only not a time to allow any slowing up of business, but is a time when every sensible process of stimulation should be used.

Cordially and sincerely yours,

(Signed) Woodrow Wilson."

(*Journal of Commerce*, June 18, 1917, p. 1.)

Society Affairs

Engineering Survey

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES[1]

OFFICERS AND COUNCIL, 1917

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W. F. M. GOSS
JAMES HARTNESS
JOHN A. BRASHEAR
D. S. JACOBUS

Vice-Presidents

Terms expire December 1917

WM. B. JACKSON
J. SELLERS BANCROFT
JULIAN KENNEDY

Terms expire December 1918

CHARLES H. BENJAMIN
ARTHUR M. GREENE, JR.
CHARLES T. PLUNKETT

Managers

Terms expire December 1917

CHARLES T. MAIN
SPENCER MILLER
MAX TOLTZ

Terms expire December 1918

JOHN H. BARR
H. DE B. PARSONS
JOHN A. STEVENS

Terms expire December 1919

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WILLIAM B. GREGORY
C. R. WEYMOUTH

Chairman of Finance Committee

ROBERT M. DIXON

Treasurer

WILLIAM H. WILEY

Honorary Secretary

FREDERICK R. HUTTON

Secretary

CALVIN W. RICE

Executive Committee of the Council

IRA N. HOLLIS, *Chairman*
JOHN H. BARR
ARTHUR M. GREENE, JR.
D. S. JACOBUS
CHARLES T. MAIN
SPENCER MILLER

COMMITTEES, ETC.

STANDING COMMITTEES

Chairmen

FINANCE, Robert M. Dixon
MEETINGS, Robert H. Fernald
PUBLICATION, Fred. R. Low
MEMBERSHIP, To be appointed
LIBRARY, John W. Lieb
HOUSE, Frederick A. Scheffler
RESEARCH, R. J. S. Pigott
CONSTITUTION AND BY-LAWS, F. R. Hutton
STANDARDIZATION, Henry Hess

SOCIETY REPRESENTATION

AMERICAN ASSOCIATION ADVANCEMENT OF SCIENCE
AMERICAN SOCIETY TESTING MATERIALS, JOINT CONFERENCE COMMITTEE
AMERICAN SOCIETY FOR TESTING MATERIALS, MODIFICATION BRIGGS STANDARD FOR PIPE THREADS
CLASSIFICATION OF TECHNICAL LITERATURE
CONFERENCE COMMITTEE ON ELECTRICAL ENGINEERING STANDARDS
CONFERENCE COMMITTEE OF NATIONAL ENGINEERING SOCIETIES
CONSERVATION
ENGINEERING FOUNDATION
EXPERT TESTIMONY COMMITTEE
JOHN FRITZ MEDAL, BOARD OF AWARD
JOSEPH A. HOLMES MEMORIAL ASSOCIATION
MILITARY ENGINEERING COMMITTEE OF NEW YORK
NATIONAL DEFENSE COMMITTEE
NAVAL CONSULTING BOARD OF THE UNITED STATES
STANDARDIZATION OF PIPE AND PIPE FITTINGS FOR FIRE PROTECTION
TRUSTEES UNITED ENGINEERING SOCIETY

[1]A complete list of the officers and committees of the Society will be found in the Year Book for 1917, and in the March, 1917, issue of The Journal.

SPECIAL COMMITTEES

Chairmen

ADMINISTRATION, Robert M. Dixon
AM. SOC. M. E. JUNIOR PRIZES, L. P. Alford
AM. SOC. M. E. STUDENT PRIZES
BOILER CODE COMMITTEE, John A. Stevens
  SUB-COMMITTEE TO CONFER WITH COMMITTEE OF A. S. T. M. ON MATTERS PERTAINING TO MATERIALS, SPECIFICATIONS, IN CODE
COMMITTEE ON ENGINEERING RESOURCES, George J. Foran
CONFERENCE COMMITTEE ON AMERICAN ENGINEERING STANDARDS
CONFERENCE COMMITTEE TO DETERMINE COST OF ELECTRIC POWER, W. B. Jackson
ENGINEERING EDUCATION
FLANGES AND PIPE FITTINGS
INCREASE OF MEMBERSHIP, A. L. Williston
JOINT COMMITTEE ON STANDARDS FOR GRAPHIC PRESENTATION, Willard C. Brinton.
LOCAL SECTIONS, D. Robert Yarnall
MACHINE TOOLS STANDARDIZATION
METRIC SYSTEM, L. D. Burlingame
NATIONAL DEFENSE COMMITTEE
NATIONAL MUSEUM
NOMINATING COMMITTEE, L. E. Strothman
PATENT LAWS
PIPE THREADS, INTERNATIONAL STANDARD, Edwin M. Herr
POWER TESTS, Geo. H. Barrus
REFRIGERATION, D. S. Jacobus
RESEARCH COMMITTEE,
  SUB-COMMITTEE ON BEARING METALS, C. H. Bierbaum
  SUB-COMMITTEE ON CUTTING ACTION OF MACHINE TOOLS, Leon P. Alford
  SUB-COMMITTEE ON FUEL OIL, Raymond H. Danforth
  SUB-COMMITTEE ON INVESTIGATION OF THE CLINKERING OF COAL, Lionel S. Marks
  SUB-COMMITTEE ON LUBRICATION, Albert Kingsbury
  SUB-COMMITTEE ON MATERIALS OF ELECTRICAL ENGINEERING
  SUB-COMMITTEE ON SAFETY VALVES
  SUB-COMMITTEE ON STEAM FLOW METERS, R. J. S. Pigott
  SUB-COMMITTEE ON WORM GEARING, Fred. A. Halsey
STANDARDIZATION OF MACHINE-SCREW NUTS (JOINT COMMITTEE WITH S. A. E.) E. H. Ehrman
STUDENT BRANCHES, Frederick R. Hutton
TELLERS OF ELECTION, Robert H. Kirk
TOLERANCES IN SCREW THREAD FITS, L. D. Burlingame
U. S. BUREAU OF MINES, ADVISORY COMMITTEE
  SUB-COMMITTEE ON MINING EQUIPMENT
  SUB-COMMITTEE IN FUELS

SECTIONS COMMITTEES

Chairmen and Secretaries

ATLANTA, Oscar Elsas, Cecil P. Poole
BALTIMORE, W. W. Varney, A. G. Christie
BIRMINGHAM, J. H. Klinck, J. G. Eatman
BOSTON, A. C. Ashton, W. G. Starkweather
BUFFALO, David Bell, William Dollar
CHICAGO, A. D. Bailey, A. L. Rice
CINCINNATI, F. A. Geier, J. T. Faig
DETROIT, G. W. Bissel, S. J. Hoexter
ERIE, J. F. Wadsworth, M. E. Smith
INDIANAPOLIS, W. H. Insley, (Secretary to be appointed)
LOS ANGELES, F. G. Pease, T. J. Royer
MILWAUKEE, W. M. White, F. H. Dorner
MINNESOTA, H. L. Brink, E. A. Wilhelm
NEW HAVEN, H. B. Sargent, E. H. Lockwood
NEW ORLEANS, H. L. Hutson, E. W. Carr
NEW YORK, J. J. Swan, A. D. Blake
ONTARIO, R. W. Angus, Chester B. Hamilton, Jr.
PHILADELPHIA, L. F. Moody, J. P. Mudd
ST. LOUIS, R. L. Radcliffe, E. H. Tenney
SAN FRANCISCO, B. F. Raber, C. H. Delany
WORCESTER, Geo. I. Rockwood, R. G. Williams

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, Its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

APART from the regular monthly departments, this issue of THE JOURNAL is practically devoted to the Sections of the Society, the Proceedings Section containing papers presented and discussed at Section Meetings, the publication of which will be continued in the next issue, and the Society Affairs Section containing reports of the year's activities received from the respective chairmen of Sections.

In reading these accounts of Sections work, members of the Society will become impressed with the increasing importance and tremendous possibilities of this activity of the Society, whereby we are able to bring the Society work in direct touch with eighty per cent of the whole membership.

Quoting from Vol. 31 of the Transactions, only eight years ago, during the presidency of Mr. Jesse M. Smith, "A meeting of members of the Society residing in St. Louis and vicinity was called by Wm. H. Bryan, member of the Meetings Committee. Prof. E. H. Ohle acted as secretary and about twenty engineers were present. This was the first local meeting of the Society to be held outside of New York City." Boston almost simultaneously held its first meeting. All the development of the Sections has come within the space of eight short years, and has now reached a magnitude that 112 local meetings were held during the season just closed.

The President, Dr. Hollis, proposes to further accentuate the national character of the Society by instituting the holding of Council meetings in various cities. The Council meeting for November will be held in Chicago. This will bring together a larger number of the officers of the Society than would ordinarily be brought in connection with one of the local meetings, it being planned to adjust the date of the Council meeting to the same day as that of the Chicago local meeting.

The President contemplates in the early fall a visit to the Coast. With this trip he will have attended meetings of the Society in all of the centers where we have established Sections.

The Committee on Sections also contemplate holding meetings next season in various cities where Sections meetings will be held. In this way an intimate knowledge will be gained of the requirements in different parts of the country. The first meetings will probably be held at St. Louis, Chicago and Detroit, during the month of October. By arranging meetings at these cities on consecutive days the committee will be able to visit several cities in one week with a saving in traveling expenses and the time of the members of the committee. These meetings will be arranged to fall on dates when the monthly meeting of the Section is being held, so that the members of the committee will not only have opportunity to meet the Executive Committee but also all members of the Section. In this way it is hoped that all Sections will be visited at least once every two years.

This will tend to bring all members into close association with the work the Society aims to accomplish through Section activities, and will also give the members opportunity to get first-hand information regarding matters of vital interest to them.

CALVIN W. RICE,
Secretary.

WHAT THE SECTIONS HAVE DONE THIS YEAR

A CLOSE association between the various local organizations of other societies representing the divisions of engineering practice and our own Sections has resulted in the holding of a large number of joint meetings during the season just closed. The largest of these meetings was that held in November 1916, when the Sections from Boston, New Haven, New York and Worcester and the Providence Engineering Society, affiliated with our Society, met with a number of engineering organizations in a visit to New London, Conn. There were over 1600 present on this occasion, and the event was described in detail in the December issue of THE JOURNAL.

The title of the Associated Technical Societies of Baltimore indicates that a plan of full coöperation of the engineering organizations has now been achieved in that city. In Buffalo our Section has coöperated with the Buffalo Engineering Society to the mutual benefit of both, while the Cincinnati Section is affiliated with the Engineers' Club of Cincinnati and takes charge of three or four of the joint meetings held each year. In Erie the Section has developed relations with the Engineers' Society of Northwestern Pennsylvania, and plans are being perfected whereby it will supply the speakers at two of the joint meetings of the season. Very cordial relations exist between the Minnesota Section and the other engineering societies of that state, and there have been joint meetings with the local branch of the American Institute of Electrical Engineers. The plan of affiliation of the Philadelphia Section with the Engineers' Club is working very successfully and Philadelphia is being pointed to as an example of coöperation of engineers. Joint meetings have been held during the year with The Franklin Institute and with the American Society of Heating and Ventilating Engineers. The meetings in Providence have been those of the Providence Engineering Society, affiliated with our Society. The Section meetings in New Orleans have been held jointly with the local branch of the American Society of Civil Engineers and the Louisiana Engineering Society. New Haven is organizing a Connecticut State Section to secure more complete coöperation, and a meeting of the Bridgeport branch of this Section has been held during the past month; the work in this state has developed a new field for Sections activities. In Atlanta the Section is coöperating with the Affiliated Technical Societies there. The Detroit Engineering Society and the local Section of our Society are working in complete harmony for the development of the profession in that busy center, and joint meetings are held by both organizations with the Detroit Branch of the Society of Automotive Engineers.

The reports from the various Sections of the year's work indicate more fully how this spirit of coöperation, of which the above are potent examples, is being developed. These reports show also how the sections are joining with local branches of the other national societies in their meetings, and are thus carrying out in an equally effective way the work which the parent societies are endeavoring to do nationally.

THE SECTIONS AND THE SOCIETY

At the Annual Meeting in December the third Conference of Sections was held, when the official delegates of sixteen Sections and the representatives of five centers contemplating the establishment of Sections met with the Committee on Sections. One session was devoted to an "experience" meeting, at which each delegate reported the work of his Section during the past year and plans for the ensuing season. The conference led to a better understanding of the problems with which each Section has to deal and developed ways and means for their ultimate solution.

The Committee on Sections also held a luncheon and business meeting at the Spring Meeting in Cincinnati in May 1917, at which seventeen Sections were represented. That the coöperation of the Sections might be even more complete, it was urged at this meeting that there be an exchange of literature and notices of meetings between the Sections.

At the Spring Meeting, also, the Committee on Constitution and By-Laws presented an amendment to the constitution recommending that the Committee on Sections be made a Standing Committee of Administration of the Society and that it have a seat on the Council without vote.

A NEW DEVELOPMENT IN SECTION ORGANIZATION

The Connecticut members are developing a new method of section organization in the nature of a State Section, with branches at the important industrial centers of the state. Heretofore the requirements of the members of that locality were met by the activities of the New Haven Section. This Section has been holding two meetings annually for some time —one in the fall and the other in the spring. These meetings were held at Yale University, and through them the Society has grown in Connecticut to such an extent that a more comprehensive program has been found desirable. This movement has, in a measure, been prompted by a feeling on the part of the members in other localities of the state that it was unjust to continuously put upon the New Haven members and Yale University the burden of arranging the meetings, because all of the members of the Society in the state of Connecticut were always invited to the meetings of the New Haven Section.

The members of the New Haven Section have set an excellent example in coöperation by not only unselfishly stepping aside to make way for the State Section, but by taking a leading part in its development.

About three months ago a meeting was held in Bridgeport at which were present members of the Committee on Sections, Secretary Rice, a majority of the members of the New Haven Section, and a large number of members of the Society representing various parts of the state. At that meeting the following organization committee was appointed: H. B. Sargent, chairman, representing New Haven; C. K. Decherd, representing Meriden; Harry E. Harris, representing Bridgeport; S. F. Jeter, representing Hartford, and E. S. Sanderson, representing Waterbury.

A formal petition has now been submitted for the establishment of a Connecticut Section, with branches at New Haven, Bridgeport, Hartford, Meriden and Waterbury. Each branch will be governed by an Executive Committee of five members, the chairmen of the five branches composing the Executive Committee of the State Section.

The Bridgeport branch organization committee met on the evening of July 16 at the Algonquin Club, and tentatively selected the following officers: H. E. Harris, chairman; F. R. Pleasonton, vice-chairman; R. W. Ellingham, treasurer; E. L. Fletcher, secretary; C. W. Burges, chairman of Committee on Increase of Membership. The other proposed branches will soon organize, so that the whole scheme may be put into effective working order by the beginning of the new fiscal year, on October first.

NEW SECTIONS

New Sections have been established during the year at Baltimore, Erie, Indianapolis, New Orleans and Ontario, the headquarters of the last being at Toronto. This brings the total number of Sections up to twenty-one.

LOCAL ORGANIZATIONS

In several cities in which the number of members of the Society is not sufficient to organize a Section, the members meet together or with existing local organizations periodically. The accounts of these meetings have been published during the year with the regular Section reports.

The Committee on Sections is anxious to extend the benefits of the Society as rapidly and as far as possible. Obviously the initiative must be taken by the members themselves, and in those centers where the numbers and interest are sufficient to warrant meetings being undertaken.

The Society through the Committee on Sections is anxious to assist in the development of Sections work and makes appropriations to cover fixed expenses.

MEETINGS AND PAPERS

In the October 1916 issue an outline was given of the proposed Sections activities for the season. A report from each Section gave the number of meetings expected to be held, trips to be taken and entertainment features planned. As far as possible the papers which were to be presented were listed, thus giving a fairly complete program of the work laid out for the year.

To a large extent the programs in each city have been carried out as planned. In all 112 meetings have been held this season, and all have been reported in THE JOURNAL. Eleven of the papers presented locally have been published in THE JOURNAL.

THE SECTIONS AND VISITS OF OFFICERS

In the fall of 1916 President Jacobus and Secretary Rice made a tour of the Sections and of the centers where members were contemplating the formation of Sections. President Jacobus delivered an address in Buffalo on the relations existing between the parent Society and its Sections and on coöperation between the Sections and local engineering societies and clubs. The places visited were Meriden, Pittsburgh, Cleveland, Buffalo, St. Louis and Baltimore.

In January of this year President Hollis visited the Sections at Detroit, Chicago, Milwaukee, New Orleans, Birmingham and Atlanta. President Hollis's message to the Sections was service of the individual to society. In March Dr. Hollis made a

second tour which took him as far west as the Minnesota Section, whose headquarters are at Minneapolis-St. Paul. En route he visited the Sections at Buffalo, Chicago and Indianapolis, receiving a rousing welcome from all. His spirited address on Service to the Country in This Crisis brought forth enthusiastic responses. He has also spoken before the members of the Sections at Boston, New York, Philadelphia and Worcester, and the Providence Engineering Society.

In April Secretary Rice supplemented President Hollis's visits by a tour to the Sections at Cincinnati, Chicago and Milwaukee, and to Madison and Oklahoma City.

The President expects to make a trip to the Coast in the fall and visit the Sections there.

SECTIONS REPORTS FOR THE YEAR

At the close of the season's work the Sections have sent in reports to headquarters giving detailed accounts of their work. Some of these reports are published below and the remainder will be included in the next issue of THE JOURNAL.

The thanks of the Society are due to the Executive Committees of the Sections whose terms of office have just expired, for the personal time they have devoted and labor spent in continuing and fostering this very important activity of the Society. To maintain the full measure of coöperation and of amicable relations with other engineering societies which the Sections enjoy calls for the exercise of a great deal of tact and perseverance on the part of committee members, and the Society has cause for congratulation because of the fine spirit in which this work has been conceived and carried out during the past season.

Sections Reports

BALTIMORE

The Baltimore Section was organized at a meeting on October 19, 1916. President Jacobus and Secretary Rice attended the organization meeting.

In organizing the Section it was realized that its work could be made much more effective if the mechanical engineers could secure the coöperation of all the other engineers in the city. It was felt that a joint organization of engineers in Baltimore would tend towards greater interest in each particular section and also in matters of general engineering interest. Steps were therefore taken at the outset to bring about such a coöperative organization. Following a number of conferences the Associated Technical Societies of Baltimore was formed of all local technical societies and the local sections of the national engineering societies. Each local organization invites members of all sections of sister societies to all its meetings, except those of a strictly business character. It is hoped that later on this association may develop a close union and that the joint organization will be one of considerable influence.

The first year of the Section's activities has been marked with many meetings of interest with such subjects and speakers as Work of the Navy Experiment Station, by W. F. DeBaufre, Mem.Am.Soc.M.E.; Recovery and Use of By-Products from Coal Tar, by F. H. Wagner, Mem.Am.Soc.M.E.: Flow of Values Through an Industrial Plant, by Harrington Emerson, Mem.Am. Soc.M.E.; Safety First on the B & O, by J. T. Broderick, and Munitions and Preparedness, by Alten T. Miller.

The formation of a Section in this city has stimulated interest in the Society, as evidenced by the increased membership during the past year; it has also encouraged the formation of a Student Branch at Johns Hopkins University.

The outlook for next fall is most encouraging and it is anticipated that the four meetings already planned for next winter will prove of even greater interest to engineers than those of the past year.

C. C. THOMAS,
Section Chairman.

BUFFALO

The Engineering Society of Buffalo was organized in 1912 from a group of members of the A. S. M. E., and by a sturdy growth it has absorbed the entire activities of the local Section. The *why* of the E. S. B. is "coöperation," the greatest force in the world today.

Today the society has a membership of over 500, comprising the various branches of professional engineering, mechanical, electrical, chemical and civil, all of which are splendidly represented. The society believes that the intermingling of engineers of somewhat different interests is broadening to all, and conducive to the greater effectiveness of the influence of engineers on questions affecting the general public welfare, as well as to the advancement of the profession nationally.

Every two weeks during the months of October to May, inclusive, meetings are called in the Hotel Statler, and the average attendance is about 200. Preceding each meeting a dinner is served to promote social intercourse of members and their guests.

Bulletins are prepared announcing all meetings, and for special meetings display posters are used. Return postal card notices of meetings are also forwarded to all members.

A practice is made of inviting the more prominent business men and heads of manufacturing establishments to the meetings.

Each year there has been an increase in interest and attendance at these meetings, but the season just closing has been marked by more ambitious programs and an even more enthusiastic attendance. In arranging the program for the year special attention was given to securing subjects of general rather than specific technical interest in order to stimulate enthusiastic support from the entire local membership. An analysis of the program shows that effort has been concentrated upon making the subjects as broad as possible, and also of special interest in Buffalo and its vicinity. A similar series is being planned for next season.

JOHN YOUNGER,
Section Chairman.

NEW YORK

Following out the plan inaugurated toward the close of the preceding year, the activities of this Section were carried out along three distinct lines: namely, the regular monthly meetings, at which papers or addresses were delivered; social evenings under the direction of the Entertainment Committee, and excursions arranged and conducted by the Excursion Committee. In each of these activities the Acquaintanceship Committee assisted, and informal suppers before the monthly meetings were also effective in getting the members better acquainted.

The regular meetings were divided between technical papers and those of a semi-popular nature, the latter this year being chiefly on military topics. The technical papers were The Development of the Poppet Valve Steam Engine, by Siegfried Rosenzweig; Standards of Business Success, by Earle Buckingham; Narrow Gage Motor Cars, by C. W. Hunt, and an address by Dr. Ira N. Hollis. Among the semi-technical were those on Explosives, by Charles L. Reese, of the E. I. Du Pont de Nemours Powder Co.; Submarines, by Mr. Charles H. Bedell of the Electric Boat Co.; Mobile Armaments, by Andrew M. Coyle, and an address by Commander E. P. Jessop, U. S. Navy.

The average attendance was about 300, with a notable increase of the younger members of the Section.

During the first half of the year the Excursion Committee, under the direction of its Chairman, carried out a number of interesting and instructive Saturday-afternoon excursions, the largest of which was the trip to the submarine base at New London, in conjunction with the Boston, Providence, New Haven and Worcester Sections; 700 members and guests of the New York Section journeyed by special train on this excursion. The committee also conducted the excursions at the Annual Meeting. Unfortunately the war condition has prevented carrying out the plans of this committee during the latter half of the year.

Among other activities of the Entertainment Committee may be mentioned an informal smoker held early in the season, and a dinner-dance at the Machinery Club in April, both of which were largely attended.

H. R. COBLEIGH,
Section Chairman.

PRESENTATION OF THE JOHN FRITZ MEDAL

THE John Fritz Medal, awarded to Dr. Henry Marion Howe in January of this year for his "investigations in metallurgy, especially in the metallography of iron and steel," was presented to him in the Auditorium of the Engineering Societies Building, New York, on the evening of Thursday, May 10.

Mr. Ambrose Swasey, Chairman of the John Fritz Medal Board of Award this year, presided at the ceremonies, and addresses were delivered by Dr. Rossiter W. Raymond, Secretary Emeritus of the American Institute of Mining Engineers, and Dr. Ira N. Hollis, President of The American Society of Mechanical Engineers.

Prof. Albert Sauveur, Chairman of the Board at the time the award was made, presented the medal, and the ceremonies concluded with the response of Dr. Howe. A full account of the proceedings at the meeting is given below.

HENRY M. HOWE

MR. SWASEY WELCOMES THE FRIENDS AND MEMBERS OF THE ENGINEERING SOCIETIES.

In welcoming the friends and members of the engineering societies, and in introducing the first speaker of the evening, Mr. Swasey said: "It is a happy privilege that we can meet here this evening to honor one of our number who has distinguished himself in the profession of engineering, and that we may call to mind that splendid, noble character for whom the medal to be presented this night was named, and for whom it was established, and also call to mind the number who have received the medal as the years have gone on.

"I am sure we can but feel that this has been an elevating influence, a broadening influence, and that today, because of the John Fritz Medal, the engineering profession in this country occupies a higher plane and has a broader horizon than ever before. It has brought the different sections of the engineering societies together in a more coöperative way than has been in the years before, and I am sure that we all rejoice that these medals are awarded as we go along through life. I would that dear Mr. Fritz could take a part in and know of the work that is being undertaken in his behalf and in his name, in which he was so much interested.

"I remember one day we went down to the studio of the sculptor and he was extremely interested in the model for the medal which is to be presented this evening. He took much interest in every detail, not only as to the obverse, but as to the reverse side of the medal. In many ways he was identified with this work, and it is a great pleasure to think of him, of his sweet ways, and of the interest, not only as a great engineer, but of the great broad man he was in every respect, and I may say that we appreciate the noble works of those who have received the medal since his day, and we are glad to have one of the medalists with us here this evening in addition to the one who is to be the recipient of the medal that is bestowed this evening.

"I am sure you will be interested to have me read the names of those who have received the medals from time to time:

"The first was John Fritz, then came Lord Kelvin, George Westinghouse, Alexander Graham Bell, Thomas Alva Edison, Charles Talbot Porter, Alfred Noble, Sir William Henry White, Robert Wilson Hunt, John Edson Sweet, James Douglas, Elihu Thomson, and this evening Henry Marion Howe.

"This certainly is a splendid list of members and a great honor roll. Many have passed on, have ended their work here, and others are still going on with the work, but the names and the memories of those who have passed away still abide with us, and now this evening as we take up the ceremonies of presentation of the medal, I am going to first call upon one who needs no introduction, because you all know him because of the splendid work that he has done, for what he has accomplished for the engineering profession. We all have a deep affection for him, and therefore I am going to simply present to you Dr. Raymond."

DR. RAYMOND PRESENTS A FITTING TESTIMONIAL TO THE ACHIEVEMENTS OF PROFESSOR HOWE

Dr. Raymond, with his intimate knowledge of the life and the work of Professor Howe, delivered a very interesting and forceful address which is reproduced in full below:

"The genesis of a new science or branch of science is in this wise: First there is the invention of some new means or method of investigation, such as the chemical laboratory, the telescope, the microscope, or the spectroscope, followed at once by an innumerable host of startling, confusing, mostly qualitative observations. Such an invention reveals to mankind a dazzling but vague new world, the very existence of which was scarcely suspected before, and the indefinite outlines of which inspire poetic generalizations, and vast hypotheses—beautiful if true—beautiful, indeed, irrespective of their truth.

"Then comes the long period, less thrilling yet not less meritorious and even more important, during which the means and methods of observation are rendered more precise, and the recognition of differences more minute. At the same time, the older data are revised, corrected, and assorted—many,

probably most, of them, being rejected. This is the stage of preparation of the raw material of the science; and it is characterized in every science by the accumulation of a well-nigh intolerable burden of distinctly separated facts. But this burden must be patiently borne, and the separate units of which it is composed must be delimited, measured and weighed, in order that the mathematical, that is, the quantitative, character may be impressed upon them. Illustrations of this principle will occur to all who have followed the growth of any science.

"General Myer, the creator of our U. S. Weather Bureau, once told me that when he began to organize that service at Washington, he found in the garret of the Smithsonian Institution tons of old papers containing 'weather observations' contributed by public-spirited citizens all over the country who had heroically got out of bed at certain hours to read their thermometers, rain gages and weathercocks and anemometers. But nobody had tested or standardized their apparatus, and nobody guaranteed its freedom from accidental aberration or mischievous meddling.

"I have heard also of a great German mineralogist, who made many thousand measurements of crystals, and based upon their varying angles some beautiful hypotheses. But after his death, another mineralogist tested his goniometer, and found in it defects which vitiated his observations.

"Such are the pseudo-materials of science, which must be got out of the way before safe induction can begin. But even really scientific data may present, during the stage of verification and inchoate arrangement, an overwhelming complexity, which threatens to smother a new science in its cradle. Take, for instance, the condition of biology before Wallace and Darwin. Everybody was furiously busy detecting differences, and founding upon them the definitions of new species; and the mere catalogues of species were beyond the student's comprehensive grasp. We all remember the universal sigh of relief with which the scientific world, welcoming the Darwinian hypothesis as its new guide, began to study similarities and relationships instead of differences, and saw the incalculable multitude of individual species group themselves in a grand order, illuminated by a new law.

This emergence of a general formula from a chaos of equations marks the final stage in the genesis of a science. That is not the end, but only the beginning, of its history. It must still grow by accretion, subdivide by fissile separation, and establish its relations to other sciences. And at every step the operations of observation, verification, criticism, analysis and synthesis must be repeated, just as the embryo rehearses in miniature the history of a species.

"It follows that the stages of development which I have indicated, though they may seem, on the large scale, to follow one another, really go on *pari passu*. There is no time at which any one of them ceases. Yet with regard to a single and limited branch of scientific inquiry, their existence and succession may be clearly discerned.

"It is my difficult but honorable and welcome task to set before you an outline of the work of a master who has contributed mightily to all these phases in the growth of the new science of metallography: as a discoverer and observer, as an industrious compiler, and as the builder of a noble edifice out of the materials thus gathered and prepared.

"It is not my purpose to give a complete biographical and bibliographical statement. But I must say here at least so much as will indicate the peculiarly fitting endowment and environment by which this life and its work were determined and perfected.

"Henry Marion Howe was born March 2, 1848, at Boston, Mass. His father was Dr. Samuel G. Howe, famous for his service to Greece in her war for independence (from 1824 to 1830) and later for his labors in the instruction of the blind. His mother was Julia Ward Howe, author of the Battle Hymn of the Republic, and leader in many reforms. He was of good stock on both sides, making him heir to intellectual keenness and refinement, the capacity for both enthusiasm and perseverance, a passion for the pursuit of knowledge, and a gift of clear and felicitous statement.

"This inheritance was improved by a liberal education. No matter how vehemently the business or scientific value of a 'college course' may be controverted, I notice that, without exception, the successful men who have had such a course are glad they had it, and those who have not wish they had. We may be sure that Professor Howe's easy command of his field in technical literature owes much to the circumstance that he was graduated in 1865 from the famous Boston Latin School, and, four years later, received his degree as Bachelor of Arts from Harvard College. Thus equipped, he entered the Massachusetts Institute of Technology, which gave him in 1871 the degree of Graduate in the Department of Geology and Mining Engineering—a cumbrous title for which the institution substituted, a few years later, that of Bachelor of Science. And Harvard made him Master of Arts in 1872, and Doctor of Laws in 1905.

"But upon this basis of wide and liberal culture it was necessary to his future achievements that he should lay another foundation of acquaintance with practice; and this he did during the next dozen years, as a student in the steel works at Troy, manager of works at Pittsburgh, and designer and builder of the works of the Orford Nickel and Copper Co. at Capleton and Eustis in the province of Quebec, and at Bergen Point, N. J. His experience in the metallurgy of copper bore legitimate fruit in the publication at a later period of his first book, Copper-Smelting; but before this appeared (in 1885) he had already become known through his technical papers as an acute observer and reasoner, by no means averse to friendly controversy.

"Since it is my present duty to offer not so much a symmetrical and complete account of Professor Howe's activities as a description of the particular labors in recognition of which he receives today from his brother engineers the John Fritz gold medal, I shall pass lightly over the general features of his career, merely observing that from 1883 to 1897 he resided at Boston, and, besides his private practice as a consulting metallurgist and expert witness in metallurgical patent suits, was lecturer on metallurgy at the Massachusetts Institute of Technology; that in 1897 he was called to the professorship of metallurgy in Columbia University, from which position he retired in 1913 with the title of Professor Emeritus; and that for the last ten years he has declined as far as practicable all professional business, in order to devote himself exclusively to the completion of what had clearly become the great scientific mission of his life. To this end, he has maintained at his own expense a special laboratory of research.

"It gives me pleasure to fancy, whether or no the fancy be also fact, that I remember the beginning of that mission, forty-odd years ago. In 1871, the first year of the existence of the American Institute of Mining Engineers, Mr. Howe, then just graduated from the Massachusetts Institute of Technology, became a member of the new organization. His two earliest contributions to its Transactions, Blast-Furnace Economy, in Vol. III, and Thoughts on the Thermic Curves of

Blast-Furnaces, in Vol. V, indicated already that he was making a scientific study of practice. But between the dates of these papers a famous controversy was inaugurated in the forum of the Institute by the brilliant paper of Alexander L. Holley, *primus inter pares*, entitled What Is Steel? In this controversy, eminent metallurgists like Wedding, chemists like Prime, and expert captains of industry like Metcalf, vigorously took part; but of all the knights in the tourney, none rode a straighter course or laid in rest a sharper lance than Howe, whose paper on The Nomenclature of Iron ardently advocated a scientific as distinguished from a commercial nomenclature. To tell the truth, the battle had a commercial origin. The real question at issue was not, What *is* steel? but, What may fairly be called steel at the custom house? And the technical reputation of the Institute was invoked by one party in favor of a convenient, practical, industrial classification which would relieve importers from the expensive refinements of science.

"Well, there was even an international committee on the subject, and the committee made a report, and the report was not adopted by the Institute, except provisionally for optional use in its publications, because the Institute was wisely deemed to be an arena of discussions and not a tribunal of decisions. Never was a more fortunate position assumed, for the great question was left open, as it should be always. The tariff difficulty was adjusted somehow; the antagonists shook hands; the thunder of the captains of industry and the shoutings died away. But one man continued the inquiry fiercely in his own soul. Henry Marion Howe, before whom the dust of the controversy loomed like a giant Afrite still defying attack, devoted his life thenceforward to the mighty conundrum, What is steel? That he has spoken the last word—even his own last word—on the subject, no one would venture to say; but certain it is that he has brought us to a degree of knowledge the very existence of which was scarcely dreamed in 1876.

"It is curious that at that time he insisted upon the capacity of steel for hardening as an essential element in classification. For it was through this door—the study of the conditions and nature of the hardening process—that the advance was to be made into the wider field of knowledge. And the instrument of knowledge was to be the new science of metallography.

"That science, at least so far as it relates to iron and steel, may be said to have begun with the observations of Sorby on the microstructure of iron, reported in 1864 and 1868. Martens published independently in 1878. But already in 1868, Tschernoff had enunciated the chief laws which govern the metallography of iron. These were supplemented by the appearance in *Stahl und Eisen*, 1885, of Brinell's laws. All these creditable steps of progress were rendered more or less uncertain and incomplete by the imperfection of the apparatus and methods of precision, by consequent errors of observation, and by gaps in the data—though the aggregate quantity of material was already overwhelming. Then came in 1887 and subsequent years the remarkable investigations and intuitions of Floris Osmond, who discovered that metals frequently combine to form definite chemical compounds, and that these compounds frequently form solid solutions. He discovered also the thermal critical points of iron, and, interpreting these changes in the cooling curve as indications of some molecular change, propounded the brilliant hypothesis of the allotropy of iron which furnished the acceptable allotropic theory of the hardening of steel. To him, as Professor Sauveur remarks in his Biographical Notice of Osmond (Trans. A.I.M.E. xlv, p. 274), we owe likewise the discovery of austenite, the non-magnetic solid solution of iron and carbon existing above the thermal critical range, and the transition constituents, martensite, troostite and sorbite, marking as many distinct and important steps in the transformation, on cooling, of the solid solution austenite into the ferrite-cementite aggregate.

"This brings us to the date of Howe's first book on the subject; and the history of the new science, as I have already sketched it in general terms, is epitomized in the essays and books of Professor Howe from the appearance of his Metallurgy of Steel in 1888 to that of his Metallography of Steel and Cast Iron in 1916. The first of these books was an amazing accumulation of reported facts, tabulated, verified and explained as far as was then practicable. The last is an equally amazing array of facts, but now sifted, tested, logically arranged and luminously interpreted, exhibiting not uncomprehended differences, but significant similarities and relationships. The first was a heap, parts of which had been sorted; the last is an edifice. To produce the first required intelligent and inexhaustible industry and critical discernment. The second exhibits the creative genius of an architect. Between the two lies the history of a science, to every stage of which this builder has made some important contribution. Let me mention a few of these, under the heads of invention of improved methods; discovery of new facts; testing of data; and correlation and interpretation of observed phenomena. I shall not pretend to comprehensive completeness in this survey. I must be content with the exhibition of typical samples.

"One of the new methods invented by Professor Howe is that of determining the microstructural and other conditions which exist in steel at high temperatures by fixing those conditions through the process of quenching—a method which has been generally adopted, and by the use of which much clearer and more trustworthy results have been obtained than were formerly possible.

"Among his discoveries of new facts may be mentioned the isotropy of the effects of plastic deformation (announced in 1888, and supported in 1914); the possibility of effacing blowholes in soft steel by welding (1909); the relations of graphite flakes in cast iron, representing, not complete discontinuities of the metal, but only the filling by graphite of the interstices in ferrite skeletons; and the crystallography of the slip planes (Metallography of Steel and Cast-iron, p. 327).

"But this investigator kept himself acquainted with the discoveries of others. In 1893 he confirmed by rigorous experimental proof the brilliant hypothesis of Osmond that the transformations in steel represent the alternate acquisition and loss of hardening capacity.

"Under the head of testing and verifying data, I would name the rigorous analysis of the so-called Clapp-Griffiths process; the demonstration that the chief benefit of rolling and forging is due to the low finishing temperature rather than to the degree of mechanical reduction, as formerly believed; and the striking demonstration that the results of one of the most important investigations of the gas evolved from iron were wholly vitiated by the leakage of the apparatus. All these may be found in the Metallurgy of Steel, which contains also analyses of the conditions of dephosphorization, of the chemistry of the crucible process, and of the technique of Bessemer practice.

"In a remarkable paper on the structure of steel, contributed to the proceedings of the American Society for Testing Materials for 1911, Professor Howe collected into the

form of propositions or laws the observed relations of heat treatment to the microstructure and mechanical properties of steel. In that paper he enunciated twenty-three of these laws; and had he then ceased from his labors, his work would have followed him as an imperishable record indelibly carved upon the history of science. But he was destined to go still further during the five years which followed. His latest book, The Metallography of Steel and Cast-iron, published in 1916, occupies intellectually a higher plane than its predecessors, by which I mean that it commands a wider outlook, permitting grander generalizations, and the recognition, in due perspective, of causes, effects and relations. This book, in short, exhibits that simplification which I have described as following the stage of maximum complexity in the development of a science. Its very title, coupling steel with cast iron, expresses the maturer view which includes both in one continuous series, subject to the same laws—a significant conclusion of the controversy which began with the contention that steel was not cast iron. Not that the difference has been disproved but that a higher unity has been shown to embrace it. Such is indeed the normal end of controversy—'peace without victory' through agreement on a higher level.

"This book is not a textbook, repeating what is generally accepted already. Covering the field in which others have meritoriously labored, it propounds, suggests and prophesies new truth and new views of truth. It is a product of the two kinds of genius, the genius which consists in an infinite capacity for taking pains, and the genius which with happy intuition surveys, divines, coördinates and interprets the cosmos in the chaos.

"That my estimate of the work of our great American colleague, as summed up and set forth in this book, is not merely an expression of personal affection or patriotic pride, let me prove by one or two opinions from eminent authorities.

"I would quote first a few paragraphs translated from a review of the book by Professor Le Chatelier in the *Revue de Metallurgie* (Vol. xiii, No. 2, March-April, 1916):

> The new work of Mr. Howe is entirely original. It has nothing in common with the numerous treatises on metallography which have appeared during the last ten years. Whoever has read one of them has read them all. Here we have to do with the personal observations and views of the author. As he indicates in his preface, he has written this treatise, not to state the solidly established principles of a young science, but to cause the creators of that science themselves to think; to open before them new horizons. Hence he has not feared to announce theories sometimes a little hazardous. . . .
>
> This study will make an epoch in the history of the progress of science. It represents many years of uninterrupted research, but for a much longer period it will certainly be consulted by investigators with fruitful results.

"The following remarks are taken from a similar review by H. C. H. Carpenter, Professor of Metallurgy at the Royal School of Mines, South Kensington, England:

> It is quite safe to say that Professor Howe's book will at once take its place as an authoritative, and indeed, classical, exposition of the field of knowledge with which it deals. From whatever standpoint it is judged, it is a great book—great in its power, lucidity, balance, comprehensiveness, and preëminently scientific character.

"In a private letter, written with reference to the announcement that the John Fritz medal was to be conferred upon Professor Howe, the same distinguished author says that he believes no award could have given greater pleasure to the metallurgists of Great Britain, who look upon Professor Howe not merely as the *doyen* of metallographists in America but as their most distinguished representative; 'a worker whose single-mindedness in the pursuit of truth is an example to us all, and whose conscientiousness gives to his publications a character of their own.'

"Finally, I take the liberty of quoting from a private letter received by me from a no less eminent American, Prof. Albert Sauveur himself, who, as the President of the Board of Award, bestows this medal tonight:

> Professor Howe, in his recent masterly book on The Metallography of Steel and Cast-iron reviews exhaustively and examines critically, as he alone can do, every view at all worthy of recognition, dealing with the subject he covers. I believe that any responsible author who has ever expressed a reasonable opinion on any subject dealing with the metallography of iron and steel will find his views recorded and discussed in this book. Professor Howe then proceeds to weigh with great fairness and extraordinary intelligence and lucidity the arguments or evidence supporting the different views, and draws his conclusions accordingly. His method is that of a mathematician solving a problem in which each factor is given its proper value. In this way, Howe has rendered to metallurgists an inestimable service; and he alone could render it. Where most of us could see only chaos and obscurity, he is able to bring order, and to discover the light that, under his skillful manipulation, soon illuminates the darkest corners. . . .
>
> This, I think, is his greatest achievement—the marvellous coördination which he has brought into the science of metallography through his genius and his labor, tremendous in quantity, marvelous in lucidity. To him more than to any one else we owe the quick rejection of weak or ill-supported theories in favor of the survival of the fittest—a process so necessary to the advance of any branch of human knowledge.

"To these expressions of individual and representative opinion should be added the numerous formal honors bestowed upon Professor Howe by institutions and governments in many lands. England, France and Russia have each conferred three of these recognitions, while others have come from Germany and Sweden. And, last but by no means least to his patriotic heart, come two announcements, received since I began the preparation of this address, the one, of his election as a member of our National Academy of Sciences; the other, of his selection as one of the charter members enumerated in the proposed Act of Congress incorporating the American Academy of Engineers.

"Thus the applause of two continents attends the act of the John Fritz Medal Committee in selecting Henry Marion Howe as a recipient of that great honor. And the act has also another significance. It is a recognition on the part of engineers that the microscope and the test tube have become the tools of engineering. Indeed, when we remember that the strength of materials is the alphabet of every branch of engineering science represented by the givers of this medal, we must admit that the man who with microscope and test tube analyzes the causes and determines the conditions of that strength is among the greatest of engineers.

"While this testimonial is bestowed by engineers, I cannot forbear to utter my satisfaction that it is received by one who is more even than an engineer; whose many-sided patriotic and literary activity is typical of this age, in which engineers are, as St. Paul said of the Gentiles, 'no more strangers and foreigners, but fellow-citizens with the saints.' If we may say of him, as Johnson said of Goldsmith, '*non tetigit quod non adornavit*,' we may almost add, '*non est, quod non tetigit*.'

"And so we crown to-day with grateful pride, not only the leader, but also the comrade and friend!"

DR. HOLLIS EULOGIZES THE RECIPIENT OF THE MEDAL

Expressing his opinion that the spirit of the meeting should lead us to a new dedication of ourselves to the service of mankind, Dr. Hollis said: "It is not only a privilege, but also

an honor, to have a share in the award of the John Fritz Medal to Henry Marion Howe for his contributions to applied science. This medal as a recognition of achievement in applied science has completely justified itself if it has served no other purpose than to record in this admirable way the practical service to science. But it does more in calling attention to the great value of research. The popular conception of invention as a mere happy guess or thought has led many into a totally false conception of the method by which applied science has grown. As a matter of fact, practically all of our advancements have been the results of patient study and research, the work of developing a thought always being the harder and better part of it. In calling attention to the method by which Mr. Howe's great work has been accomplished, this meeting serves to educate and to clear the popular mind on the true value of scientific research and of the abstract study of all science. Not one of the recipients of the John Fritz Medal has earned his right to distinction by mere thought. Each one of them has worked, and worked steadily through his life, with some definite end in view, usually without much thought of the money side of his discovery. In this respect Mr. Howe is a worthy successor of all those who have preceded him on this honorable list. His work has been done quietly and modestly without the help from daily papers that has become so disturbing and, in some cases, so disastrous a part of the scientist's achievement in these later years. He is not only a fitting successor to all the men who have received the same honor, but he is also beyond all others of the same family as John Fritz. No professional man has ever earned lasting fame who has not obtained it through the high respect of those in his own profession. It is not the printing press and the public who make the reputation of a great man, but rather his companions in the profession who understand his work. Mr. Howe is thus singularly happy in the friends who have gathered around him tonight to rejoice with him. They will remember and understand well what he has done for the science of metals and for his country as well. As a teacher, a writer, and a scientist, his life is a speaking example of science wisely and unselfishly used in man's service. He has given and published freely his discoveries and his ideas on steel so that all his fellow citizens might benefit alike. There has been no touch of the baneful search for power through money. Without being an announced leader in scientific management, his work in teaching the industries the value of special steels, in adapting the means to the end, has been a great contribution to safety and efficiency.

"He has pointed out the path. Sometimes by simply indicating where the path enters the unknown, a teacher opens the way and leads others from traditional methods to new and better things. Life is made up of wandering pathways, and some great pathfinder stands at every parting. James Watt was at the beginning of modern industry, George Corliss at the first great departure in the economical use of steam, John Fritz lived to see his work culminate in the great Bethlehem Company. All the others on the list of medalists have found themselves at the beginning of an era in their subjects and now Henry Howe joins these immortals who have stood as the great teachers and pathfinders of mankind.

"Nothing that I can say here will add to his reputation. That is written in his books. This great meeting should, however, lead us to a new dedication of ourselves to the kind of service so much needed toward the rational life of man of this planet.

"Science has three aspects: first, to discover truth and follow it; second, to employ the forces and materials of nature for the good of all mankind; third, to set us into closer accord with the will of God.

"It is not necessary to dwell on these, except perhaps the last, which is the only pure science that we have. In these days of struggle for power, in these days when the white races are using their scientific knowledge to weaken one another, to destroy one another, it is well for us to search our hearts for those things in which science has been found wanting. At times we have made a god of it, with the thought that it alone has brought the human race out of darkness, that it has dispelled the shadow of superstition, and by promoting the well-being of man it has formed a true civilization. We sometimes forget that no civilization can continue to exist in an unbalanced condition. Science alone would make of this a hard, cold world, just as all intellectuality without heart tends to mere machinery. There are always two sides to a shield. Well-being and comfort without the spirit of self-sacrifice destroy rather than promote an enlightened civilization. It is well, therefore, on an occasion like this to give some thought to the religious side of life, and by religious I mean that kindly spirit brought into the world by Jesus Christ 1900 years ago. Nothing that the world has done or that science has produced is comparable with His one precept as the chief motive by which men can live. We may consider this great struggle going on in Europe, into which we ourselves are plunging, as the greatest thing that ever happened in this world, and yet it is insignificant by the side of that appealing life that ended on the cross so many centuries ago. 'Love thy neighbor as thyself' is the best inheritance of the race, as it is the chief hope of the future. Science is valuable only in so far as it vitalizes and strengthens that one principle, because we care nothing for new inventions, we care nothing for the comfort of men, and we care still less for the possible support of a greater population, if the soul be dead. Only so far as science promotes true democracy (not political democracy) and that love of men which will make wars impossible and eventually turn the lawyers into farmers is it worth while. In 1900 years it has done something toward making possible Christ's reign on earth. The famine areas of the earth have been reduced by the development of transportation and the communication by telegraph. Where there is a shortage of crops, we can quickly rush aid and supplies, and the world is generally willing to give a small percentage of its gain. It has remained for science to develop the most effective method of destroying the whole yield of a harvest, and plunge it into the bottom of the sea, so that it is only just to say that the human race has developed no international conscience. The organization for relief is still in its infancy, and there is only enough Christianity left to provide help more or less spasmodically. Another direction in which science has promoted Christianity is in preventive medicine, and in hospitals that have been established for all kinds of infectious and inherited diseases.

"But, after all, we have just touched the fringes of a real civilization, in which righteousness will be the guiding principle for nations, as well as for men. When the best minds are devoting themselves to the invention and construction of machinery and chemicals for killing men on a great scale, we are very far from loving our neighbors as ourselves. Science has therefore done as much to enslave as to emancipate, and we have not yet learned that its votaries are worshipping only half of the truth. Unless the engineer and those who profit through his work can be brought to realize that everything produced through science is held in trust for humanity, we shall make no progress. Our country will be plunged more and more into that

lethargic, luxurious state which can be cured only by the shedding of blood. Already we feel in this war a certain impulse of regeneration, and we need it. Our country has been called 'dollar mad' by Europe. Almost everything is judged from the one single basis of money. A book is good only if it sells. Fortunately there is one place into which this surrender has not penetrated: that is the teaching profession, and Mr. Howe's life well illustrates the kind of altruism that will bring us a happy regeneration, and a more lasting peace than we shall ever get through the blood of war. A better democracy must come through science. Men must learn to be ashamed to accumulate wealth through invention. No privilege by birth and no inheritance through the patent office should stain our democracy. No king can love his neighbor as himself, no great land owner who has the peasant on his farm can ever feel that the creature who toils is exactly like himself. This great war then is a war against false doctrine. Its end must be that greater democracy which teaches men unselfish service to one another, without which the race is not worthy to remain, and without which it ought to disappear. Only so far as science strengthens righteousness will it contribute to the great task before us as a free people.

"We see some signs in our country of a true enlightenment. The wealthy desire to give. Our privately owned colleges and schools are supported in large part by generous men who believe that their wealth is a public trust. It is only a gleam of light, however, for the percentage of giving is extremely small, and our problem will not be solved until we attain that enlightenment which makes it a duty for every man to give. We must think of invention and science and wealth as the mere instruments through which the individual is enabled to benefit the race. It is important that we should consider this whole question now, because the treaty of peace that must eventually come will ask for an answer. Science and Christianity must join hands to find some means by which the problem of a larger life can be solved between nations, as between individuals.

"Our profession has an ethical purpose, and it will fail if it does not see clearly that its place is not with science alone. Under various names it has been the one great constructive profession since reason began to develop in the creatures on this earth. Its history is practically the history of the human race. The political struggles have but recorded the advance of science in one form or another. To us as a profession, therefore, is confided the great task of enabling men to live on this planet under the theory that the highest happiness is attained through love, rather than through force. Organization is a science, as important as the machine. Life itself is the greatest of sciences. We must contribute our share.

"My chief reason for dwelling on the moral aspect of science, especially on that side of it which promotes the practical application, is that Mr. Howe's career well illustrates the motive that must always lie behind the engineer's work, if our profession is to live and to be found worthy."

PROFESSOR SAUVEUR THEN PRESENTS THE MEDAL. ADDRESS OF PROFESSOR SAUVEUR

Professor Sauveur made a brief introductory allusion to the municipal reception of the French mission, at that moment taking place at the Public Library. He thought it a happy coincidence, in view of Professor Howe's early, earnest and persistent advocacy in public and private of the cause of the Entente Allies. Then, turning to the subject of the evening, he continued: "After what you have heard there can be no doubt left—if any doubt ever existed—in anyone's mind as to the wisdom and discrimination exercised by the John Fritz Medal Board of Award in selecting its medalist for 1917.

"There is nothing that I could add to what has been so ably—yea, so brilliantly—told by Dr. Raymond. To me, however, as Chairman of this Board at the time the award was made, is assigned the delightful duty of actually presenting the John Fritz Medal to Professor Howe.

"Henry Marion Howe, son of an illustrious father and of an illustrious mother,

Lover of justice and of humanity,

Public servant and public benefactor,

Master of the English language,

Loyal and devoted friend,

Untiring and unselfish worker in an important field of science,

Stimulating teacher, inspiring investigator and generous collaborator, hundreds have been guided by the light radiating from your pen, encouraged by your kind words, dazzled it is true, but also stirred to further and more vigorous efforts by the heights you reach,

Voyager in realms but dimly perceived by your fellow-workers,

Lone explorer of fields destined to yield rich harvest to future generations,

Man of genius, honored and loved the world over,

By authority of the Board of Award, I now place in your hands the John Fritz Medal."

REPLY OF PROFESSOR HOWE

"It is not to me but to the bright unbodied image which you have created, to the foster child of your chivalry and your leniency, that these more than generous words apply, that this noble memorial is due. I thank you from the bottom of my heart on his behalf, while on my own I thank you as warmly for his acquaintance, for the hope that it may kindle into an inspiring friendship, letting me 'grapple him to my soul with hooks of steel,' and above all for this incitement to further and vigorous striving, holding with Ulysses that

> 'Old age hath yet his honor and his toil;
> ——————————something ere the end,
> 'Some work of noble note may yet be done.'

"To prolong thanks is so thankless that I might well now hold my peace were it not for the world crisis, ever in our consciousness. This so presses for our best thought that attention to other matters suggests fiddling while Rome burns. For Rome truly is in flames. We are as a family in a burning home. Democracy itself is at stake.

"This conflagration should arouse Americans all the more because it is a necessary and integral part of the train of events which our forefathers started when those

> 'embattled farmers stood,
> And fired the shot heard around the world.'

"In that shot was stored the whole process of the liberation of man, including today's tragedy, as surely as the history of the oak, its growth, its majesty, and its fall, are stored in the acorn. The example of our freedom not only incited the more plastic peoples to democratization as in France and Britain, but also started a process of selection leading straight to this death grapple between democracy and autocracy. For by selection those most impatient of despotic control, those of greatest initiative, in short the most independent from all other

lands, immigrated to us and to the other democracies induced by our example, leaving as a residuum the less independent, the more docile.

"The democratizing impulse of our example, aided as it was in France by hunger and by outraged manhood, and in England by royal fatuity, was irresistible. But in Prussia it was so far weakened by material comfort created by the skill and craft of her kings that it failed, and in failing exaggerated this process of selection.

"That failure found the Teutons without those influences which in France and Great Britain temper the selection by emigration, the inborn domesticity of the French, and the closeness of the ties between Britain and her colonies, which leads great numbers of her sons to send their children back to school, and to return to the motherland later in life when their adventurousness has spent itself, thus restoring to the nation much of its more adventurous blood which the dreams of youth send abroad. Because Germany was intensely autocratic and without hope of democratization, she lost by emigration not only the most adventurous and independent, but even a vast number of those of intermediate independence, to our great gain. Thus the mean docility of the residuum was exaggerated. Because Germany lacked colonies these emigrants identified themselves with the countries to which they went, and renounced allegiance to their land of birth, so that the submissiveness of those left at home was undiluted by the return in later life of the more independent stock.

"It is this exaggerated docility, resulting thus irresistibly from the selection started by our liberation, that has led to this terrible struggle. For it has enabled the Hohenzollerns and Hapsburgs, through their Nietzsches and their Treitschkes, through a cunningly devised state education appealing to all the baser motives, to ensnare the Teutons, drunk with vanity and new riches, in the intellectual slavery implied by their adopting the monstrous doctrine that might makes right, with all its sickening corollaries, its frightfulness, its foulness, and its treachery,

> 'hideous as the deeds
> Which you can scarce hide from men's revolted eyes.'

"It is this docility, with the resultant intellectual enslavement, that has enabled these autocrats to weld their people into a mass so coherent, so blindly unquestioning, as to strike with an initial force wholly disproportionate to their numbers when compared with those of democracies, whose units, however strong individually, cohere but feebly in every-day life because of their individualism.

"It is this frightfulness, it is this depth of depravity and cruelty engrafted on all Teutonia through this same process, that has added incalculably to the danger that autocracy will win, by frightening into neutrality or even into ill-concealed coöperation Germany's small neighbors who are our natural allies. Such a victory, leaving the Hohenzollerns and Hapsburgs still in power, could at best be followed by a truce between two armed camps, autocracy and democracy, during which the world would be putting all its available energies into arming for a renewal of fighting.

"Slow as we have been to understand that this struggle is something more than the latest of the European wrangles 'whose obscure sources do not interest us,' once we let our eyes be opened, once we saw that a great moral principle was at stake, we resolved that as it was we who had begun the extirpation of autocracy, so we must share in carrying this work to its triumphant end, not because any other course might well leave us to fight Teutonia singlehanded but because we are determined that 'government of the people, by the people, for the people shall not perish from the earth.'

"Our efforts should be quickened by the thoughts that though the means of creating men cannot in the nature of the case be hastened, those of destroying men can be accelerated to an indefinite degree by the applications of science. The very qualities which have enabled man to better himself at a rapidly accelerating rate by his inventions, the steam engine, anesthesia, the sewing machine, the motor car, the telegraph, the telephone, and wireless telegraphy, are capable of being used to increase at an equally accelerating rate the means of slaying him. From the enormous increase in the powers of human destruction in the few decades since Sedan we get but a first foretaste of what man is inherently capable of inventing. We are indeed shocked at the new and higher order of destructiveness of this war, but our imagination fairly reels in trying to conceive the still higher order of ruin of future wars, should autocracy stay in the saddle. Those against whom this enhanced destruction, this annihilation, would be launched would not be the savage and uncivilized but the very flower of the race, those who threaten autocracy most. Because man cannot deprive his fellows of these powers of invention, he can prevent his own annihilation only by curbing autocracy, that form of government which evolves naturally through human destruction, or better by destroying it and replacing it with democracy, which evolves naturally through human betterment.

"Our problem at the end of the war will be to prevent future wars, to prevent the actual employment of the enormously enhanced destructive powers sure to evolve, to force the nations to keep the peace as we have forced individuals. To say that we are inherently incapable of preventing our own annihilation; that because the less developed past did not learn to prevent its little wars, killing their tens of thousands, the more developed future must ever remain impotent to prevent its wars with their far higher order of havoc, killing their millions, is to betray a fatalism, a pessimism as unworthy of Americans as it is foreign to our nature. To me it seems an insult to the mothers who bore us, nay, to the God who made us."

Volume 38 of Transactions

The thirty-eighth annual volume of TRANSACTIONS of The American Society of Mechanical Engineers is now off the press and will shortly be placed in the hands of the membership. The volume records the affairs of the Society during the year 1916, and includes the annual report of the Council, giving a résumé of the activities of standing and special committees, and a calendar of the 103 general and local meetings held during this period. It also contains, under 46 titles, all the papers and discussions presented at the Spring Meeting, held in New Orleans in April 1916, and at the Annual Meeting, held in New York in December 1916. The papers deal with industrial management, the appraisal and valuation of industrial property, power-plant equipment and operation, the measurement of flow of air, natural gas, steam and water, drainage pumping, hoisting and handling machinery, balancing, vibration in mill buildings, machine-tool standardization, gas producers, steam and electric locomotives, electric boiler-joint welding, etc. A Code of Safety Standards for Cranes, prepared by the Sub-Committee on Protection of Industrial Workers, is presented. Credit for these papers should be given to the Committee on Meetings, its Sub-Committees, and the Sections Committees, through whom they were secured.

Standardization of Machine-Screw Nuts

ON June 8, our Society and the Society of Automotive Engineers received a request from the Navy Department to consider the standardization of machine-screw nuts. This request was embodied in the following letter from Naval Constructor D. W. Taylor:

NAVY DEPARTMENT

BUREAU OF CONSTRUCTION AND REPAIR
WASHINGTON, D. C.

MR. CALVIN W. RICE, SECRETARY,
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS,
29 WEST 39TH STREET, NEW YORK CITY.

DEAR SIR:

The Bureau's attention has recently been directed to the fact that paragraph 8 of Navy Department specifications 42S5b specifies dimensions of machine-screw nuts which prohibit the supply of such material by other than a limited number of manufacturers. Upon investigating the question, the Bureau has been impressed with the fact that there are apparently no standardized widths and thicknesses; brass and iron, hexagon and square nuts supplied by different manufacturers vary considerably in such dimensions for the same nut number. Seven manufacturers of this material have furnished the Bureau dimensions of the nuts they make; these requirements have been tabulated in the blueprints attached hereto. The last column in each of the blueprints contains the sizes as at present appearing in paragraph 8 of Navy Department specifications 42S5b.

It would appear that it would be desirable for The American Society of Mechanical Engineers or the Society of Automotive Engineers to undertake to standardize the dimensions of machine-screw nuts, if such work, in fact, has not already been inaugurated. It is felt that the elements involved in the investigation, such as any desirable relation of the width or outside diameter of nuts to the diameter of washers, the relation between the thicknesses of nuts and the usual commercial thicknesses as rolled of sheet brass or sheet steel, etc., can better be handled by you or a similar national society than by the Bureau. A letter similar to this is, therefore, being addressed to the Society of Automotive Engineers.

The Bureau desires to express its interest in the problem, its willingness to coöperate in any way practicable, and would appreciate your comments relative to the question at issue.

Respectfully,
(*Signed*) D. W. TAYLOR,
Chief Constructor, U. S. N.,
Chief of Bureau.

After conference with the Society of Automotive Engineers, the Society accepted the duty and addressed the following reply to the Navy Department, and President Hollis appointed E. H. Ehrman, E. Burdsall and Charles Glover as a committee to coöperate with the S. A. E. Committee, consisting of E. H. Ehrman, chairman; Clarence Carson, E. S. Crawford, J. E. Diamond, W. H. Nolls, Berne Nadell, H. H. Newson and E. E. Sweet.

REAR-ADMIRAL D. W. TAYLOR, CHIEF CONSTRUCTOR, U. S. N.,
CHIEF OF THE BUREAU OF CONSTRUCTION AND REPAIR,
WASHINGTON, D. C.

DEAR SIR:

We accept cheerfully the request to standardize machine-screw nuts, and will immediately appoint a committee and coöperate with the Society of Automotive Engineers.

Yours truly,
(*Signed*) CALVIN W. RICE,
Secretary.

The Navy Department acknowledged the offer of the two societies in the following letter:

NAVY DEPARTMENT

BUREAU OF CONSTRUCTION AND REPAIR
WASHINGTON, D. C.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS,
29 WEST 39TH STREET, NEW YORK CITY.

GENTLEMEN:

The Bureau is pleased to note from The American Society of Mechanical Engineers' letter of the 9th instant, and the Society of Automotive Engineers' telegrams of the 11th and 12th instant, that the suggestion offered in the Bureau's letter that work be inaugurated in the standardization of dimensions of machine-screw nuts has been adopted. It is furthermore noted that The American Society of Mechanical Engineers and the Society of Automotive Engineers are coöperating in this problem. The Bureau is gratified indeed at the prompt response accorded the question in hand.

You will be communicated with at a later date relative to the Bureau's representative in connection with the subject at issue. It is felt that the question to be investigated is of interest not alone to this Bureau, but also to one, and possibly two, other Bureaus concerned with the suggestion that representatives be nominated to coöperate with The American Society of Mechanical Engineers and the Society of Automotive Engineers. The Bureau also feels that it will be highly desirable to have representatives of the Army and the Bureau of Standards on the Committee; it would be better, however, to have your organizations communicate with those branches of the Government direct as to any representatives which each branch might desire to nominate.

Respectfully,
(*Signed*) B. STOCKER, *Acting*
Chief Constructor, U. S. N.,
Chief of Bureau.

The joint committee met in Washington on June 23, and the Navy Department was represented by Naval Constructor J. A. Furer, U. S. N.; the Bureau of Standards was represented by Mr. L. A. Fischer, and the Aircraft Engineering Board by Mr. C. B. King.

At this first meeting a table of proposed machine-screw nut dimensions was formulated to be sent to all manufacturers of such nuts for their criticism and suggestions.

The Bureau of Ordnance of the Navy Department has nominated W. W. Smyth as its representative on this committee.

Engineering Council

At the organization meeting of the Engineering Council, held in the rooms of The American Society of Mechanical Engineers, on June 27, the following officers were elected: President, I. N. Hollis; vice-presidents, H. W. Buck, George F. Swain; secretary, Calvert Townley. Executive Committee: Those named, with J. Parke Channing and D. S. Jacobus.

The council discussed at length ways and means by which the founder societies through the council may be of use to the nation. The unanimous desire to help the Government in the prosecution of this war resulted in a resolution instructing the executive committee to coöperate with the Government in procuring the services of engineers, also in the appointment of a committee of three, consisting of Messrs. H. W. Buck, A. M. Greene, Jr., and Edmund B. Kirby, to consider the best means of utilizing the inventive ability of members of the founder societies.

The secretary was instructed to inform all Government bureaus that might be interested of the organization of the Engineering Council and of its desire to be of assistance.

CANDIDATES FOR MEMBERSHIP

TO BE VOTED ON AFTER SEPTEMBER 10, 1917

THE American Society of Mechanical Engineers is an organization for mutual service of over 8100 engineers and associates coöperating with engineers. The membership of the Society comprises Honorary Members, Members, Associates, Associate-Members and Juniors, all elected by ballot of the Council. Application for membership is made on a regular form furnished by the Secretary which provides for a statement of the standing and professional experience of the applicant and requires references from voting members personally acquainted with the applicant. The requirements for admission to the various grades will be furnished upon request.

Below is the list of candidates who have filed applications for membership since the date of the last issue of THE JOURNAL. These are classified according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to scrutinize this list with care and advise the Secretary promptly of any objections to the candidates posted. All correspondence in this regard is strictly confidential. Unless objection is made to any of the candidates by September 10, 1917, and providing satisfactory replies have been received from the required number of references, they will be balloted upon by the Council. Those elected will be notified about October 15, 1917.

NOTE. The Council desires to impress upon applicants for membership that under the present national conditions the procedure of election of members may be somewhat slower than under normal conditions. The first step in the consideration of an application is taken by the Membership Committee, and this committee is composed of busy men, with fewer opportunities to meet together in these strenuous times.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Colorado

AKERLOW, CARL G. W., Engineer in Charge of Drafting and Designing,
Colorado Iron Works Co., Denver

Connecticut

BREUL, FRED G., Owner and Manager,
Private Manufacturing Business, Design and Construction Automatic Machinery, Bridgeport

DOYLE, BARTHOLOMEW M., Chief Engineer,
Housatonic Power Co., Waterbury

District of Columbia

EICKHOFF, THEODORE H.,
Research in Ordnance Work, Washington

Indiana

HAMILTON, WILLIAM E., Efficiency Engineer,
Premier Motor Corp., Indianapolis

Massachusetts

AFFLECK, BERTRAM L., Prevocational Instructor,
City of Boston, School Department.

JUDGE, FRANKLIN, General Superintendent,
Greenfield Tap & Die Corp., Greenfield

MACOMBER, CARLTON H.,
With General Electric Co., Lynn

POWELL, ALBERT M., Consulting Engineer,
Powell Machine Co., Worcester

WHIPPLE, GEORGE F., Compiler "Catalogue Studies," Boston

Michigan

KREIDLER, DANA W., Chief Engineer, Carburetor Division,
Detroit Lubricator Co., Detroit

PERRY, THOMAS D., Secretary,
Grand Rapids Veneer Works, Grand Rapids

Mississippi

DROSS, PHILLIPP, Vice-President and General Manager,
The Marty Foundry Co., Inc., Meridian

New Jersey

ACKERMAN, ALBERT A. JR., Chief Draftsman,
The Singer Manufacturing Co., Elizabethport

HAGELTHORN, THOMAS,
436 Highland Avenue, Arlington

New York

COLLINS, EDGAR F., Engineer Industrial Heating,
General Electric Co., Schenectady

DIAMANT, SIDNEY, President,
De Mant Tool & Machine Co., New York

MCCOY, WILLIAM T., Tool Department Head,
Savage Arms Co., Utica

WILLIAMS, CHARLES S., Sales Engineer,
American District Steam Co., North Tonawanda

Ohio

CAMM, JOHN A., Vice-President,
The Cleveland Milling Machine Co., Cleveland

DOAN, JAMES B., President,
The American Tool Works Co., Cincinnati

WESCHE, BJARNE A., Owner,
B. A. Wesche Electric Co., Cincinnati

Pennsylvania

GLYNN, CHARLES V., Mechanical Engineer,
Hershey Chocolate Co., Hershey

MCBRIDE, JOHN J., Chief Export Inspection Bureau,
American Car & Foundry Co., Berwick

Washington

WITHERSPOON, WILLIAM O., Designing Engineer,
Washington Portland Cement Co., Concrete

West Virginia

JENKINS, EDWIN M., Mechanical Engineer,
Virginian Railway Co., Princeton

Wisconsin

BREED, PRESTON H., formerly with
National Brake & Electric Co., Milwaukee

KELLER, WILLIAM H., President and General Manager,
Keller Pneumatic Tool Co., Fond Du Lac

Philippine Islands

STANTON, ROBERT B., JR., Manager Mechanical Engineering Department, Frank L. Strong Machinery Co., Manila

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Connecticut

RATZKOFF, SILAS M., Production Superintendent, Gun Department,
Winchester Repeating Arms Co., New Haven

New Jersey

MCWILLIAMS, WILLIAM W., Assistant General Manager,
Aeromarine Plane & Motor Co., Keyport

New York

HORN, HARRY P., Draftsman,
General Acoustic Co., Jamaica, L. I.

ROBERTS, MORTIMER J., Sales Engineer,
Air Reduction Co., New York

Ohio

ESTABROOK, CHARLES B., Manager,
The Safety Ladder Co., Dayton

SPEAR, WALTER A., Test Engineer,
Cincinnati Milling Machine Co., Cincinnati

Pennsylvania

LYONS, KARL M., Production Manager,
Clarendon Refining Co., Clarendon

Vermont
BEAL, HENRY S., Manager of Cost Department, Jones & Lamson Machine Co., Springfield
Washington
GOFF, CLIFFORD, Machinist, U. S. Navy Yard, Puget Sound, Bremerton

FOR CONSIDERATION AS JUNIOR

Connecticut
ENGLEHART, RUSSELL J., With Winchester Repeating Arms Co., New Haven
PRYOR, WILLARD L., Assistant to Superintendent, Singer Manufacturing Co., Bridgeport
Illinois
ATZENHOFFER, ARTHUR H., Mechanical Engineer, Western Electric Co., Chicago
CLIFFORD, CHARLES H., JR., Industrial Engineer, Cooley & Marvin Co., Chicago
Kentucky
GRAY, HENRY C., Graduate Rose Polytechnic Institute, 1917, Resident Louisville
Maryland
MICHEL, RUDOLPH, Draftsman, Baltimore Oil Engine Co., Baltimore
TYSER, LEO, Superintendent Heating Division, Terminal Freezing & Heating Co., Baltimore
Massachusetts
BOLTON, WRIGHT JR., Master Mechanic, Acushnet Mills Corp., New Bedford
ELIN, MICHAEL B., Engineer, New England Westinghouse Co., Chicopee Falls
KNIGHT, EARL R., Assistant to the Superintendent on Production Work, Washburn Shops, Worcester Polytechnic Institute, Worcester
WARNER, EDWARD P., Assistant in Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge
Michigan
OTIS, J. HAWLEY, Student, Mechanical Engineering, University of Michigan, Ann Arbor
Missouri
CHOCKLEY, FRED W., Chief Draftsman, Henrici Kent & Lowry Eng. Co., Kansas City
RENKEN, HARRY J., Traveling Representative Railroad Department, Fairbanks, Morse & Co., St. Louis
New Jersey
HARMON, WILLIAM C., JR., With Calco Chemical Co., Bound Brook
New York
FRIEDKIN, GEORGE, Mechanical and Radio Engineer Superintendent, Dubilier Condenser Co., Inc., New York
MACNABB, CLIFTON E., Sales Engineer, Worthington Pump & Machinery Corp., New York
PLONSKER, MAURICE J., Machine Designer, Lidgerwood Manufacturing Co., Brooklyn
SPERRY, SAMUEL E., JR., Draftsman, Interborough Rapid Transit Co., New York
THOMAS, OSCAR A., Ordnance Department, Inspector, New York Arsenal, Governors Island, New York
Ohio
BROCKMAN, BERNARD N., Special Representative, The R. K. Le Blond Machine Tool Co., Cincinnati
GIEBEL, ROBERT L., Production Engineer, Cincinnati Milling Machine Co., Cincinnati
MONAGHAN, WALTER I., Sales Engineer, Armstrong Cork & Insulation Co., Cincinnati
SOLLER, WALTER, Fellow Mechanical Engineer, University of Cincinnati, Cincinnati
Pennsylvania
CONNELL, F. VAN BUREN, Assistant Superintendent, The Baldwin Locomotive Works, Philadelphia

APPLICATION FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Michigan
EMSWILER, JOHN E., Professor of Mechanical Engineering, University of Michigan, Ann Arbor
New York
HUESTIS, BRONSON L., Draftsman, Westinghouse Church Kerr & Co., New York
ROBERT, MONTAGUE H., Chief Engineer, Air Reduction Co., New York

SUMMARY

New applications	63
Applications for change of grading:	
Promotion from Junior	3
Total	66

NECROLOGY

FRANK FIRMSTONE

Frank Firmstone was born in Glendon, Pa., on August 29, 1846, and received his early education at the Phillips School, Easton, Pa. From there he went to the Saunders Military Academy in Philadelphia, and in 1865 was graduated from the Polytechnic College of Pennsylvania as a mining engineer.

His first position was with his father in the Glendon Co., and he was associated with this firm for 21 years. Upon the death of his father in 1875 he became general manager of the company. He resigned in 1887 and soon after became associated with the Cranberry Iron & Coal Co., Cranberry, N. C. He was president of this company for a number of years and was a director of all its subsidiary companies until the time of his death.

He was a recognized authority on engineering matters, and contributed valuable papers on blast-furnace practice to the American Institute of Mining Engineers.

Mr. Firmstone was a member of the American Institute of Mining Engineers, the American Society of Civil Engineers, the American Society for Testing Materials, the American Forestry Association, and the Engineers' Club of New York.

He became a member of the Society in 1880. He died on June 27, 1917.

JAMES JOHNSON PEARD

James J. Peard was born in New York City on July 25, 1849, and was educated in the public schools of Hartford, Conn. He left school to enter the employ of Colt's Patent Fire Arms manufacturing Co., where he learned his trade.

In 1873 he went to Providence where he worked with the Providence Tool Co. and afterward with the Brown & Sharpe Manufacturing Co. In 1876 he became a contractor in the employ of the Remington Arms Co., Ilion, N. Y., and after remaining there five years returned to the Colt company at Hartford. In the employ of this firm he gradually worked up until he became assistant superintendent in 1888 and superintendent in 1902. He retained the latter position until 1911, when he retired because of ill health.

For twelve years Mr. Peard was a member of the Board of Education of Hartford, serving as its secretary and president. He was a member of the Colt Mutual Benefit Association, which he organized and of which he was president until 1914. He was the inventor of many improvements in the products of the Colt company and was a recognized authority on firearms.

He became a member of the Society in 1891. He died on July 3, 1917.

WALTER BEVERLY PEARSON

Walter B. Pearson was born in Madison, Wis., on Dec. 2, 1861. He spent his boyhood in Wisconsin and obtained his education there, completing it with two years spent in the University of Wisconsin, where he specialized in mechanics. Upon leaving the University he went to Cleveland, where he took a position with the Warner & Swasey Co.

He left this firm to become assistant superintendent of the

Prospect Machine and Engine Co., Cleveland, resigning in June 1887 to take a position with the Kummer Engine Co. in Chicago, selling engines. Later he worked in the same capacity for Ide & Co., and for the Ball Engine Co., both of Chicago.

In the meantime he organized the Pearson Machine Co., manufacturing special machinery of his own invention and later specializing in producing and selling machine-screw products manufactured on the Pearson automatic screw machines.

In 1900 the Pearson Machine Co. was acquired by the Standard Screw Co., and in 1901 Mr. Pearson became a director of the latter company and was made vice-president. In 1904 he was elected president. Under his able management the company grew in strength and importance, acquiring in this process a number of the smaller machine-screw companies.

Mr. Pearson was a member of many clubs and societies, including the Engineers' Club of New York and the Chicago Engineers' Club.

He became a member of the Society in 1886. He died in Chicago on May 19, 1917.

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications for non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 15th of the month.

ENGINEER, technical graduate preferred, experienced in the design of open feedwater heaters, softeners, etc. Good position to right person. Write fully, giving details of experience and references. 102.

INDUSTRIAL ENGINEER—COST ACCOUNTANT. A well-established firm can offer exceptional opportunities for effective and interesting work to engineering graduates who have had substantial experience with modern industrial accounting, with special reference to manufacturing costs. In reply state age, education, experience, present and expected salary. 431.

ELECTRICAL ENGINEER possessing extensive experience with electrolytic plants for producing oxygen and hydrogen, wanted by New York concern. 811.

HIGH-GRADE MAN having a technical training desired by company with factory in western Maryland in the capacity of assistant designer and works manager. Duties to assist in designing special machinery and developing ideas; analyze machine operations, prescribe equipment and devise means to effect speedy and economical production; superintend the manufacturing of such machinery. Requires the ability of a thoroughly practical master mechanic with original ideas as to methods, a knowledge of modern shop practice, familiarity with the design and application of time-saving fixtures, executive ability and diplomacy necessary to successfully direct a manufacturing plant. No question of salary if the right man applies. State full particulars and technical experience with the assurance that such information will be held as confidential and no investigation will be made with present employer prior to conference. 958.

DESIGNERS. Men experienced in steam-engine and turbine work preferred. 967.

DRAFTSMEN, technical graduates, familiar with design of power-station installations, steam piping and a fair amount of structural work. State age and experience. Location Brooklyn. 990.

DRAFTSMEN AND DESIGNERS. Expeerienced men with some knowledge of valves and fittings; good future with large concern. State experience in full, salary expected and references. Confidential. 1002.

DESIGNER, familiar with pumps, blowers, heating and ventilating systems, for concern in Rochester, N. Y. 1008.

YOUNG DRAFTSMAN required immediately by manufacturer of power-plant specialties. Must be technical graduate and have had shop experience. One familiar with feedwater heaters preferred. Exceptional opportunities to acquire knowledge of design and production. Rapid advancement. Location Pennsylvania. 1013.

DRAFTSMAN. Young engineer, preferably a technical graduate with about a year's practical experience, who could work into a good position. Salary, $25 to start. Location New York. 1080.

DRAFTSMEN desired by firm manufacturing railroad specialties. Location New York State. 1084.

YOUNG ENGINEERING SALESMAN, not over 28 years of age, on application of steam specialties. 1089.

OPERATING CHIEF ENGINEER in charge of paper mill—man thoroughly familiar with boiler plants who is capable of making study of furnace conditions and tests. Salary $2500 to $3000. Location New Haven, Conn. 1129.

ESTIMATING ENGINEER. Prefer to secure a man of such age as not to be likely to be drafted for military service. Position requires a fairly comprehensive knowledge of construction work, a thorough knowledge of pumping machinery, piping and preferably concrete work, also qualifications that will enable a man to estimate on more or less complicated special machinery. Location New Jersey. 1130.

DRAFTSMEN experienced in ordnance work, particularly small arms and machine guns, or experienced in complicated automatic machinery. 1131.

COMBUSTION ENGINEER. Duties primarily those of efficiency work in the burning of fuel and generation of power, also in the use of power in the various departments of plant. Power plant is of 4000 hp. capacity, with extensive distributing system for air, steam and electricity. Excellent opening for a man interested in steam power-plant work. State fully qualifications, training and experience. Location New Jersey. 1133.

GRADUATE MECHANICAL ENGINEER with knowledge of centrifugal machinery—preferably fans, pumps and compressors—and also thoroughly familiar with their design and methods of testing same. Apply by letter. Location New York. 1140.

RECENT MECHANICAL ENGINEERING GRADUATES. Must have initiative and capacity for plenty of hard work in design, construction and operation of gasoline plants for large independent oil company. Location Oklahoma. Expenses paid. 1141.

MASTER MECHANICS, ASSISTANTS, INSPECTORS, ETC., in the construction and operation of a large shipyard. The organization must be completed as soon as possible. Location Pennsylvania. 1146.

SUPERINTENDENT OF CONSTRUCTION for mechanical equipment, including power plant, of hospital and medical college in Peking, China, for group of 14 buildings. Work will be installed by day labor and clients desire capable executive to act as superintendent for installation of such equipment. 1147.

1917 GRADUATE IN MECHANICAL OR ELECTRICAL ENGINEEERING for drafting and estimating work in connection with blast furnaces and mines. Location East Tennessee. 1152.

DRAFTSMAN for steel company. Position will be interesting, as there is a lot of new work started. Location New York State. 1153.

DRAFTSMAN. Work includes a wide range of designing machinery for roofing manufacture, conveying, foundations and plant layout. Location Perth Amboy, N. J. 1154.

DESIGNER, between 25 and 35 years of age, with mechanical and electrical engineering knowledge and sufficient shop experience to enable him to design apparatus so that it can be economically manufactured. Some pneumatic engineering experience desired, but not absolutely necessary. Work: improvement of present product in regard to increasing the quality of finished article. Design of new products now in process of development. Salary $1200 to $3600, depending entirely upon the man and his ability. Location Hoboken, N. J. 1155.

DRAFTSMAN on agricultural machinery for positions in either Porto Rico or Santo Domingo. Write fully stating age, experience, salary required and whether married or single. 1156.

SHOP SUPERINTENDENT for machine shop manufacturing planers, lathes, etc., and employing 200 to 300 men. Confidential. 1158.

GENERAL FACTORY EXECUTIVE. High-grade mechanical engineer wanted for position of works superintendent having direct charge of all power and maintenance work in a factory of over two thousand employees. Applicant must be able to show that he has made good previously in a similar position and must have pronounced executive and machine-designing ability. A desire to work harmoniously with organization a prime qualification. In first letter state age, salary and complete record of experience. Location, New York district. Permanent position for a real man. 1162.

COMPETENT MAN, about 35 years old, to take hold of maintenance and machine repairs and general shop economies. Prefer one who has had technical education and enough shop experience to understand the operation of all machine tools, and who has a full appreciation of the value of time on an operation without going into any efficiency work. Opportunity for advancement and eventually an executive position. 1166.

SALESMAN for mechanical apparatus. Salary depends on man. 1167.

DRAFTSMAN experienced in laying out dies. Permanent position. State previous experience and salary expected. Location New Jersey. 1170.

SALES ENGINEER for Spain desired by export house. Must be an experienced man who has actually sold machinery in that country. Must be competent to develop efficient sales organization, appoint subagents, etc. A substantial profit share will be paid in addition to salary, exceptional opportunity. Address applications in Spanish or English. 1172.

SALES ENGINEER for France desired by export house. Must be an experienced man who has actually sold machinery in that country. Must be competent to develop efficient sales organization, appoint sub-agents, etc. A substantial profit share will be paid in addition to salary, therefore an exceptional opportunity. Address application in French or English. 1173.

MECHANICAL ENGINEER familiar with general machinery in woodworking and machine shops to take charge of drafting room. Concern at present planning ship ways, and the work for this particular engineer will be the laying out of the woodworking shop and the machine shop, as well as derricks, cranes, etc. Location Pennsylvania. 1175.

INSPECTOR. Energetic, capable young man as inspector in plant manufacturing small machinery and machine parts. Should have had experience as a machinist. State initial salary expected, age, experience and qualifications. Good opportunity for advancement. Location New Jersey. 1183.

ENGINEER in drafting and engineering department. Able man with technical training wanted, familiar with structural work and machine design; conveying-machinery experience will be of advantage. Splendid future for right man. State fully particulars of education, experience, age, salary expected, etc. All letters regarded as confidential. 1185.

SALES ENGINEERS. Men of at least 34 years of age, with college education or its equivalent, who have had mechanical training and shop experience in the sales department of a prominent manufacturer of pneumatic machinery. Good opportunity for the right man. Give references, experience and salary expected. 1187.

DRAFTSMAN with sufficient experience to enable him to take charge of the making and checking of detail drawings in a drawing room employing two or three men. State qualifications and past experience fully. Large part of the work will consist of routine calculations. Applicants must be possessed of technical training. Salary about $150 per month. Location New York State. 1189.

FACTORY EXECUTIVE, technically trained, about 30 to 35 years of age, for large textile-machinery manufacturing plant. Knowledge of up-to-date shop methods essential, also successful experience in the handling of mechanics. Applicant would be required to spend from one to two years in shop to become familiar with the various classes of work, after which the position of assistant superintendent with further excellent opportunities for promotion will be open to him. Salary at start, about $2500. Location Mass. 1191.

ASSISTANT SUPERINTENDENT. Man about 30 years of age, who has worked his way through a technical institution along mechanical or chemical lines. Duties partake of the nature of assistant superintendent without such official title. Position requires application and long hours, and affords inducement and opportunity for pay beyond the starting wage. Salary to start, about $25. Location Virginia. 1192.

YOUNG DRAFTSMAN. Location Jersey City, N. J. Salary $20. 1193.

YOUNG ENGINEER to work up and report on shop efficiency. Salary $20. Location Jersey City, N. J. 1194.

TWO YOUNG ENGINEERS: One a recent graduate with some electrical-engineering training, at a salary of $90 a month; the other with some experience in drafting-room work, salary $125 per month. Location, New York. 1197, 1198.

YOUNG DESIGNER on jigs and fixtures. Salary $125 to start. Prefer young man with some shop experience. Location New York. 2000.

YOUNG TECHNICAL ENGINEER for sales work on fans, blowers, turbines. Need not have had previous experience in sales line. Salary to start, $1500. 2001.

TOOL DESIGNERS capable of designing jigs and fixtures on machine-tool equipment from the piece-part drawings. None but first-class men will be considered. Salary $35 per week; transportation charges paid. Location Middle West. 2004.

EXPERIENCED TOOL DESIGNERS. Familiar with tools, jigs and fixtures for miscellaneous machine shop production work, including turbines, reduction gears, guns and gun carriages. Attractive offer to capable man. Location Maryland. 2006.

DESIGNER of centrifugal pumps capable of taking charge of department in established concern manufacturing pumps for special conditions. State age, experience and references. Location Pacific Coast—New York City conference. 2008.

MAN 30 to 35 years old, preferably with some experience along manufacturing lines and capable of working into responsible position in short time. Opening is with well-established concern in New England, manufacturing variety of metal articles and novelties. Give full details of education, experience, positions held, salary expected, etc. 2009.

DRAFTSMAN with at least five years' experience in the detail of machine parts. State age, experience, salary expected, and give references. Position permanent. Location near New York City. 2012.

CHIEF DRAFTSMAN with executive and engineering ability, competent to direct the work of eight draftsmen and superintend design of output of plant manufacturing large tankage, steel mill buildings, zinc-smelter equipment and cement-mill work, along engineering lines. Must be competent to operate system now installed in relation to billing, routing and ordering materials. Want man with at least ten years' experience in manufacturing lines. Salary $2000. Location Kansas. 2013.

MANUFACTURING COMPANY has openings and invites applications from men of engineering experience familiar with design of plate, mechanical and construction work. These openings offer permanent positions and exceptional opportunities for men who are competent to prepare drawings, write bills of materials and shop orders and requisition materials for this class of work. Salaries entirely contingent on ability to produce results. Location Kansas. 2014.

DRAFTSMAN for general design of new machinery and improvement of existing machinery in large going plant. Position leads to industrial-management work. Write giving full particulars. Location Maine. 2020

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 15th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

INDUSTRIAL PLANT ENGINEER. Technical graduate, age 32. Nine years' experience in design, construction, operation and main-

tenance of industrial plant and power plants. Specialized in heating and ventilation, refrigeration and drying of materials. H-269.

MECHANICAL AND ELECTRICAL ENGINEER of fifteen years' successful practical experience. Can design, supervise or organize original or new work where initiative, tact or perseverance are required. Can furnish best professional and character references. Temperamentally qualified to adapt self to various personnel within or without an organization. At present employed, but desires new connections where there is ample opportunity to produce results. H-270.

ASSISTANT OR ASSOCIATE PROFESSOR OF MECHANICAL ENGINEERING. Technical graduate, degrees of B.S. and M.E. Age 27, married. Two years' experience as assistant superintendent of manufacture with illuminating gas company, in charge of labor and mechanical equipment. Experience in drafting, heating and ventilation work and as assistant to a consulting engineer. Three years' experience teaching mechanical-engineering subjects. Desires position with a progressive college or university for the year beginning September 1, 1917. H-271.

MECHANICAL ENGINEER. Columbia graduate, age 37, married. Fourteen years' service in motive-power department of large western railroad, in testing laboratory, as draftsman, assistant engineer of tests and assistant mechanical engineer. Desires opportunity for advancement and greater responsibility. At present employed. H-272.

MECHANICAL ENGINEER. Technical graduate, with knowledge of Spanish and experience in power plant and sugar mill, desires position as manufacturer's representative, power-plant engineer, sugar-mill engineer or instructor in a technical school. H-273.

MECHANICAL ENGINEER, EXECUTIVE. Age 32, married. Ten years' experience. Aggressive and courageous, having an excellent record and many reliable references. At present employed as head of the engineering department of a large manufacturing firm. Would like position in engineering, production or sales department of commercial firm. Available on short notice. Salary expected, $2500 per year. H-274.

SALES ENGINEER. Graduate mechanical engineer having charge of New York territory for the past ten years for well-known company manufacturing factory equipment would like to make a change. At present employed. Highest references. H-275.

ASSISTANT TO EXECUTIVE. M.E., Cornell, age 31. Experienced as a machinist, draftsman and foreman. Desires position as assistant to an executive in a manufacturing or engineering firm where there will be an opportunity for advancement. H-276.

DESIGNING ENGINEER OR ASSISTANT TO EXECUTIVE. Mechanical engineer, university graduate, not liable for military service. Fourteen years' broad experience in the design and construction of special machinery, tools, jigs, etc., including ordnance, design of ammunition-handling devices, hydraulic machinery with automatic controlling attachments, structural-steel design and specifications. Familiar with shop methods and follow-up work. Thoroughly practical, with executive ability; not afraid of work or responsibility. Available on short notice. H-277.

RAILWAY MECHANICAL ENGINEER. Age 38. Technical education and 18 years' experience as railway machinist, draftsman, chief draftsman and mechanical engineer. Desires position with railway company, railway-equipment manufacturing company, supply house or industrial plant, with greater responsibility and opportunity. At present employed. Location immaterial. Salary $3000. H-278.

MECHANICAL ENGINEER OR SUPERINTENDENT. American, 14 years' practical and theoretical experience. Specialist in valves, fittings and engineering specialties of all descriptions; machines, tools, fixtures and equipment for same, shop maintenance; efficiency and production engineer. Successfully held positions and has references verifying above experience. H-279.

SALES ENGINEER. Age 32, technical graduate. Four years' experience selling power-plant equipment as well as in design, erection and operation. Good executive ability. H-280.

MECHANICAL ENGINEER for industrial plants. Six years' specialized work on steam and combustion equipment. Desires position as works engineer or superintendent. H-281.

TECHNICAL GRADUATE, M.E., Columbia, age 27. Three years' factory experience erecting and repairing sugar-refining machinery. One year doing master-mechanic work in an acid plant. At present a draftsman. Desires position in munition or other manufacture. H-282.

MECHANICAL ENGINEER with metallurgical training desires position as assistant metallurgist. Four years' shop experience. H-283.

INDUSTRIAL ENGINEER. Age 33, married, technical education. Two years' practical shop experience, 4 years in drawing room, 3 years designing and erecting mill buildings and machinery. At present employed as mechanical engineer with manufacturing company. Can furnish best references. H-284.

RESEARCH ENGINEER AND COMMERCIAL DESIGNER on gas and oil engines, farm tractors or marine motors. Employed in experimental engineering department of a university in Central Northwest. Desires position in commercial or educational research laboratory or large factory devoting entire time to research or research and design. Originative ability in application of scientific principles. Active member Society of Automotive Engineers. H-285.

MECHANICAL-ELECTRICAL ENGINEER. Columbia graduate, age 32, married. Desires position as works engineer. Ten years' experience in industrial-plant engineering, including the installation and operation of power-generating, transmission and receiving apparatus, and shop machinery. Also experienced in the application of electricity to shop processes, welding, electric heating, pyrometry, etc. H-286.

HEAT-TREATING AND RESEARCH ENGINEER. Graduate M.E., age 33, married. Seven years' experience in heat treatment of all kinds of steels. Shop and research experience in large munition factory. Can take full charge of all heat-treating and pyrometer testing. H-287.

MECHANICAL ENGINEER. Columbia graduate, 1912. Five years' experience in design, construction, and inspection with prominent concerns. Desires position in engineering department, or as assistant with good chance of advancement. Employed at present. Salary $1800 to $2000. H-288.

GRADUATE of university mechanical engineering course, age 26, desires position with a manufacturing plant or steel works where chances for advancement into the business end are good. H-289.

SALES PROMOTER. Successful specialty sales manager and salesman, especially good on introductory work, is open for high-grade connection. Enthusiastic, convincing talker, with initiative, stability, good appearance and judgment. Accustomed to handle large business; age 37, American born, single, technically educated, with practical experience. Has covered territory from New York to San Francisco. Will go anywhere. No objection to long trips. H-290.

EXECUTIVE OR WORKS MANAGER. Mechanical engineer with wide experience in positions as executive manager and engineer. Specialty, small arms and interchangeable parts production; last six years' work has been in that line. Position in East preferred. H-291.

EXECUTIVE position in the steel business either in the manufacturing or sales end desired by an American, technical graduate. Age 36; married. Fifteen years' experience in steel plant, general construction and varied engineering work. At present employed. Will arrange for New York interview. H-292.

MECHANICAL ENGINEER. American, 33, married. Technical education. Experienced in standardization work in manufacture, in design of heavy machinery, structural work, concrete. Engineer of construction. Especially experienced in power-plant construction and in combustion engineering. H-293.

MANUFACTURING EXECUTIVE desires to locate with progressive organization producing mechanical or electrical material. Has executive and practical experience in engineering and efficiency methods, costs, inter-department systems, tools, machinery, equipment, power, labor-saving methods, quantity production. Available after one month's notice. Location New York or vicinity. H-294.

BOILER MAN fully conversant with every detail of design and construction of steam boilers, particularly water-tube boilers, oil burners as well as automatic stokers, building, erecting, static and efficiency tests. Will be open for responsible position by August 20. Location near New York City. Highest references. H-295.

STEAM-TURBINE ENGINEER. Fifteen years' experience in the design, manufacture, testing and operation of all commercial types, especially small units, in U. S. and abroad. Desires to make a change. H-296

ENGINEERING SURVEY

A Review of Engineering Progress and Attainment in Mechanical Engineering and Related Fields, Including a Digest of Current Technical Periodicals and a Selected List of Engineering Articles

National Committee on Gas and Electric Service

SOME months ago the Committee of the American Gas Institute to Coöperate with the Government in regard to the Military Needs of the Nation and the Committee of the National Electric Light Association on War Conditions, at a joint conference held in New York City, decided to organize a National Committee which would secure to the United States Government the most effective coöperation in the conduct of the war from the gas and electric light and power industries. The National Committee on Gas and Electric Service was thereupon organized with a membership of representative men from these two industries and the related natural gas industry. The Committee, as constituted, has the following members of The American Society of Mechanical Engineers on its roster:

JOHN A. BRITTON, Vice-President, Pacific Gas and Electric Company, San Francisco, Cal.

ALEXANDER DOW, President, Detroit Edison Company, Detroit, Mich.

CHARLES L. EDGAR, President, Edison Electric Illuminating Company of Boston, Mass.

A. E. FORSTALL, President, American Gas Institute, New York, N. Y.

D. C. JACKSON, Professor of Electrical Engineering, Massachusetts Institute of Technology, Boston, Mass.

S. S. WYER, Consulting Engineer, Natural Gas Industry, Columbus, Ohio.

JOHN W. LIEB, Vice-President, The New York Edison Company, New York, N. Y.

The Committee is recognized by the Advisory Commission of the Council of National Defense as one of its advisory committees, and it has established an official headquarters in the Munsey Building, Washington, D. C., where it has placed itself at the service of the Government for any assistance it may be able to render in behalf of the public-utility industries it represents. It is prepared to act as a vehicle of communication between the various instrumentalities organized by the Government for the conduct of the war and the gas companies producing and distributing artificial and natural gas and the electric light and power companies furnishing electric service, in all matters relating to the national defense. It proposes to place promptly at the disposal of the Government any data or information which it may require as to the facilities in men or service which they may have available, to insure the continuous operation of their plants so as to enable the munition plants, navy yards and manufacturing establishments, through continuous and uninterrupted service, to maintain their maximum output, and it will endeavor to provide the Government with the necessary quantity of the essential by-products they can make available for the production of high explosives and of ammunition.

One of the most essential requirements in the coördination of the industrial resources of the country for the successful conduct of the war is to provide a regular and adequate supply of fuel to the important utilities engaged in enterprises through which they render service to the Government and to the public. To facilitate solving the many problems affecting the continuous supply of fuel to operate their plants, the National Coal Board has been pleased to appoint Mr. George M. Elliott, Secretary of the Committee, to membership on the Coal Committee. A questionnaire has been prepared and forwarded to every gas and electric light and power company in the country, asking them to send a statement of the various kinds and quantities of fuel each uses per annum for its various purposes, the water or rail connections over which they are received, together with a monthly statement of fuel contracted for, received and consumed. This will enable the Committee to give prompt information to the authorities of fuel shortage in any particular locality, with the transportation lines involved, loading and unloading delays, car shortages, routing and trans-shipment difficulties, etc.

Scientific Research in France

IN a paper under the title Organization of Scientific Research in France, presented by Henry Le Chatelier to the Academy of Sciences, the author bitterly complains of the slight estimation in which science is apparently held by society and government in France. He states that men of science are never consulted on measures of public interest, even those most directly connected with science, such as, for example, problems of organization of public education. He claims that science is not appreciated in France to the same extent as it is in Germany. There the captains of industry are proud of the right to prefix the title of Doctor. In France a man who would follow the same custom would make himself ridiculous. In England industrial magnates are quite flattered at being invited to preside at meetings of scientific societies. But that could not be done in France.

Curiously, even while we in America consider our state of research as quite backward, Le Chatelier, whose name, by the way, is quite well known in this country as that of the inventor of the pyrometer and other instruments and the author of many valuable papers on metallurgy, cites the United States as one of the examples of a progressive country where research is generously endowed.

In France there is one magnificent institution of research, the Pasteur Institute, of which the country is proud, but only one. As regards laboratories created specifically for industrial research, there is only the Experimental Station of the Coal Mines Committee at Lievin, maintained by the Coal Mines Company. While this laboratory is very well equipped, it does not make much of a showing as compared, for example, with the numerous laboratories of the German syndicates, metallurgical, mining, ceramic, cement industries, etc.

A field in which still more remains to be done is the creation of private-plant laboratories serving the needs of individual concerns. According to the statement of the writer, a good many industries completely neglect the use of laboratories and none knows how to fully profit by them.

When one comes to consider ways and means to remedy this deplorable situation, one finds that the main difficulty is the skepticism of the educated classes in French society with respect to the reality and usefulness of science.

One often hears engineers, even those who have arrived at high positions in the industry, say: "Our study of science has never been of any use to us. It is nothing but good mental gymnastics, the same as fencing exercises are good bodily, even if one does not intend to use the art for actual purposes of fighting. Perhaps even the study of Chinese might prove of more value than that of mathematics."

Such statements are a clear proof of an incomplete scientific formation. The war, however, has thrown a vivid light on this subject and has shown in France, even if somewhat late, the exact state of affairs.

The principal error in the past has been that science was reduced to a collection of facts and laws; that is, to only the results of science, and in the presence of the immense number of problems facing the industry only a few of these results acquired with so much effort could be utilized in the course of the career of an engineer. Therein lies the explanation of the apparent uselessness of the study of science. But, side by side with the results there is the method of science, that which produced these results, and this method contrary to what is the case with the results themselves can be of daily application. It is to training in this way that the teaching of science should be exclusively devoted. It is not enough to clutter the mind with a variety of bits of knowledge; what should be done is to give it a certain formation.

This point of view being admitted, certain consequences immediately result therefrom. The basic method of physical sciences is the experimental method, and it is acquired in the laboratory and not in front of a blackboard. Therefore, the extension of laboratories, or rather their better utilization, as there are already a good many of them in universities, should apparently be the dominant problem in all reforms of our system of tuition. (*Revue de Métallurgie*, vol. 13, no. 3, May-June 1916, p. 161 and following.)

Changes in Boiler-Plate Specifications

As a result of an investigation by the Bureau of Standards of the requirements of the Steamboat Inspection Service for steel boiler plate, the interesting fact has been developed that the specifications heretofore in force have been unnecessarily severe and may be safely relaxed so as to increase the output without in any way lessening the safety of this material. Following the Bureau's report the executive committee of the Board of Supervising Inspectors of the Steamboat Inspection Service, at a meeting recently held here, has adopted a series of amendments in the general rules and regulations.

One of the most important changes recommended by the Bureau of Standards is the raising of the sulphur limit in open-hearth steel from 0.04 to 0.05 per cent. No change is made in the phosphorus, the amended rule reading as follows:

> Open-hearth steel shall contain not more than 0.04 per cent of phosphorus nor more than 0.05 per cent of sulphur.

The Bureau also recommended the adoption of a new rule relating to tensile-test specimens and quench-bend specimens which has been adopted, as follows:

> Two tension tests and one quench-bend test shall be made from each plate as first rolled from the billet, slab, or ingot, the tensile-test specimens to be taken from the diagonal corners of the plate, and the quench-bend specimen to be taken from that part of the plate which represents the top of the billet, slab, or ingot.
>
> The quench-bend specimen shall withstand, without fracture, being bent over until the ends are parallel and the inner radius equal to one and one-half times the thickness of the test specimen.

Section 18, Rule II, all classes, of the general rules and regulations, has been stricken out and a modified rule for determining the working pressure on flat surfaces of boilers has been adopted.

All the amendments agreed upon by the Board of Supervising Inspectors will be embodied in detail in a circular letter entitled "Sixth Supplement to General Rules and Regulations," which will be issued within a few days by the Steamboat Inspection Service to boiler manufacturers, manufacturers of boiler plate, steamboat companies and others. The circular may be obtained on application to United States local inspectors of the Steamboat Inspection Service. (*The Iron Age*, vol. 100, no. 2, July 12, 1917, p. 79)

New Navy Specifications for Steel Castings

NEW specifications governing the manufacture of steel castings have recently been issued by the United States Navy Department. They are dated May 1, 1917, and are designated as 49 Sld, superseding those issued June 1, 1916. The chemical and physical properties demanded by those specifications are as follows:

Grade	Percentage Chemical Composition (not over)		Physical Requirements				
	P	S	Minimum Tensile Strength, Lb. per Sq. In.	Minimum Yield Point, Lb. per Sq. In.	Minimum Elongation, Per Cent in 2 in.	Minimum Reduction of Area, Per Cent	Bending Test [2] (not less than)
F[1]	0.05	0.05	85,000	53,000	22	35	120 deg.
A	0.05	0.05	80,000	45 per cent of tensile strength obtained	17	20	90 deg.
D	0.05	0.05	70,000		22	30	120 deg.
B	0.06	0.05	60,000		22	30	120 deg.
C	0.06	0.07	....	....	..	..	.....

[1] Grade F castings may contain nickel or other alloying metals.
[2] Cold bend about an inner diameter of 1 in.

It will be seen that the sulphur requirements are not over 0.05 per cent in all grades of castings except Grade C, which is not tested in any way.

Grade A is intended for all important parts subject to crushing stresses or surface wear only, such as hawse pipes, chain pipes, turret roller paths, engine guides, slippers, etc.

Grade B is intended for parts subject to tensile or vibratory stresses, such as stems, stern posts, stern tubes, rudder frames, struts, engine bedplates, cylinders, gun-mount stands, carriages, slides, and other parts subject to the shock of recoil.

Grade C is intended for gun mounts, such as brackets, levers, wheels, etc., not subject to shock of recoil, and for commercial fittings where structural strength and separation of watertight compartments are not involved, such as pipe flanges (other than bulkhead and deck), cagemast fittings, stowage lugs and clips, hinges for doors and hatches where watertightness is not involved, etc.

Grade D is intended for the same general purpose as Grade B, but where greater strength is required with equal ductility.

Grade F is intended for castings for gun yokes, gun-mount stands, carriage slides, deck lugs, etc., of large size.

The latest specifications of the Navy for structural steelwork, dated Feb. 1, 1917, and designated as 48 Slc, demand not over 0.05 per cent sulphur and phosphorus in all steel castings used in yards and docks and similar work and limit the sulphur to 0.045 per cent for rivet steel for bridges and buildings.

It is known that in many cases it has been difficult to meet a sulphur specification of not over 0.05 per cent in recent months, even in acid open-hearth work. The intensive stress for output under which blast furnaces and coke plants have had to operate has tended to increase rather than diminish the quantity of sulphur in these raw materials, thereby making it still more difficult for steel makers to meet specifications. (*The Iron Age*, vol. 100, no. 2, July 12, 1917.)

News of Other Societies

Annual Meeting of the S. P. E. E.

THE twenty-fifth annual meeting of the Society for the Promotion of Engineering Education was held in Washington, D. C., July 6 and 7, in coöperation with the Committee on Engineering and Education of the Advisory Commission of the Council of National Defense. The main topic of the meeting was the relation between the engineering schools and the national Government during the present emergency. An ambitious program was prepared which featured a number of addresses by government officials, by engineers rendering service at Washington on various public and semi-public committees at this time, and by representatives of foreign governments also on business in the capital. Considering the important calls upon the time of these men, the program was very satisfactorily carried out and there were but one or two disappointments.

The trend of opinion at the meeting was that students in engineering courses should be urged to continue their studies to completion rather than enlist in the national service, since by so doing they would ultimately become of much greater use to their country as trained specialists. On the other hand, the schools themselves should possibly devise means of speeding up their work so that men could complete their courses in less time and in consequence more men would be available. Opinions were also expressed that the engineering schools should introduce military instruction into their curricula.

President G. R. Chatburn occupied the chair during the meeting, and at the opening session greetings from Canada were extended by Dr. A. S. Mackenzie, president of Dalhousie University, who recited the mistakes of Canada at the outset of the war, especially in regard to the men in her engineering schools, and hoped this country would profit by the lesson Canada had learned.

Dr. S. P. Capen, specialist in higher education of the U. S. Bureau of Education, discussed the resolutions passed at a meeting of college presidents called by the Advisory Commission of the Council of National Defense. He considered it especially desirable that a comprehensive policy of coöperation between the colleges and the Government be established and maintained.

Dr. Hollis Godfrey, member of the Advisory Commission of the Council of National Defense, delivered an interesting address upon The Consulting Engineer in Public and Private Service, in which he reviewed the construction of the Council of National Defense, a body created to "coördinate the industries and resources for the national security and welfare." He spoke of the consulting engineer in his relation to the Government and of his place in making effective governmental organization and machinery in time of war.

The Hon. Newton D. Baker, Secretary of War, pointed out the duty of engineering schools in war. He said in part:

> The progress in the art of war is from day to day, not from year to year. There is almost lightninglike rapidity in ingenuity being fed to the troops at the front. There must be the same sort of response by the engineering scientists of this country. All must learn by constant reading and study, by evolving and bringing to as near completed form as may be advantageous to our efficiency and safety.
>
> In addition to that, the larger subject is the relation of engineering education and technical education to the prospective needs of the country. We are in need of fresh accessions of trained young men from the technical schools of the country. Our Coast Artillery and our engineer departments are in constant need of large accessions and they can get them at their very best from the schools. It therefore becomes the necessary thing that the great engineering schools of the country should in large part contribute to the actual organization of the Army in peace time a substantial part if not the major part of peace-time preparation for our defense should aggression force us into defensive action.
>
> I hope, therefore, that it will be assumed that one of the functions of the colleges and technical schools ought to be so to modify their curricula that the young men who have special aptitude for the scientific things which are useful in military science will have an opportunity to develop their aptitude and bring their talent to the aid of their country either for peace-time preparation or in an emergency such as faces the country now.
>
> So that my suggestion is that all of the engineering and scientific talent of the country—and the utmost pressure should be devoted—study the solution of the scientific problems presented by the war. You ought to expedite the training of young men for immediate use by the Government in this great emergency, and you ought to look forward for the future to a large contribution of your great engineer schools and colleges and collaborate the training so that it will be very easy for the young men to render a maximum assistance to the Government if the emergency comes.
>
> Nobody knows what the world is going to be like when this war is over. No imagination is able to picture the sort of civilization the world will have after this conflict is over. Nobody knows how long this war is going to last. But we do know that when this war is over the rehabilitation of a stricken if not paralyzed civilization is going to be a long-drawn-out and uphill task, and there will be need on every hand for trained minds, for trained and schooled men. That day of the engineer will be indeed the big day. Men should then be present in very great numbers to help bring about the rehabilitation of industries, the reconstruction upon an earth which has been swept by an all-consuming conflagration.
>
> And so I think you ought to have as an especial object the urgent invitation to young men of America to come into your technical schools and devote themselves to engineering branches of education; so that when this war is over the struggle will not have been in vain; so that young men can quickly and efficiently play a part in that reconstruction.

Brig. Gen. W. M. Black, Chief of Engineers, U. S. A., emphasized that for the good of the country the four-years' course in the engineering schools should be kept up and that men should not be graduated "half educated." He also thought we had enough men in the country without taking trained specialists "to shoulder a musket." Classes should keep right on with their work as in normal times, but of course if any young men particularly wanted to go to war, let them go.

Dr. Philander P. Claxton, U. S. Commissioner of Education, expressed his opinion that every man in the technical schools should remain there until he had completed his course, unless he left to do some work that could not be well done by some other person.

Commander Cluverius, U. S. N., described the methods adopted at Annapolis to speed up the courses and graduate men. He suggested that the schools along the Atlantic coast giving courses in marine engineering could do very effective

work by teaching the practical operation of steam engines and boilers.

Among the speakers were also Dr. W. P. McClellan, director of the Intercollegiate Intelligence Bureau, who described the work of the Bureau in getting graduates to fill positions in the civil service and in the enlisted service; Dr. S. W. Stratton, director of the U. S. Bureau of Standards, who described in an interesting manner the diversity of problems coming before the bureau; Civil Service Commissioner Galloway, who conveyed an idea of how the Commission is meeting the great demands now being made upon it by government departments for men; Mr. Frank B. Gilbreth; Prof. W. F. Durand, member of the National Research Council, who described the work of the committee on engineering of the Council; Prof. A. L. Williston; Dr. George Smith, of the U. S. Geological Survey, who emphasized the Government's great need of topographical engineers; Prof. H. Wade Hibbard; Dr. F. H. Newell, who pointed out the great shortage of engineers in state and city service; Prof. I. W. Lichfield; Prof. W. M. Thornton; Prof. W. G. Raymond; Prof. F. P. McKibben and Prof. F. H. Constant; Dr. J. A. L. Waddell.

On the second day a number of committees of the society, including those on engineering, education, physics, chemistry, English, mechanics and hydraulics and economics, reported the progress of their work.

At the close of the meeting Dean Milo S. Ketchum was elected president of the society for the ensuing year, and the retiring president, Dr. Chatburn, delivered his presidential address, entitled Our Patriotic Duty. Dr. Chatburn reiterated the necessity for speeding up the college courses, making any changes necessary in the curricula and then, if the war proves short, changing back again.

Society of Automotive Engineers

THE S.A.E. held a two days' meeting on June 25-26 in Washington, momentous in the history of the society both because of the important problems considered and because of the very hearty and active participation of the Government. The idea of holding the meeting at the nation's capital was shown to be distinctly proper. As *The Automobile* (June 28, 1917, to which credit should be given for an excellent account of this meeting) states, there was hardly a report of the Standards Committee and not a single paper that was not strongly touched with the influence of the war problems on the nation.

The meeting opened on June 25 with the Standards Committee section at the Bureau of Standards Building, and was attended by a large number of members of the society who were not members of the Standards Committee. This had the good result of familiarizing the membership with the work done by its Standards Committee before the resolutions were brought up for action by the general society. Hence, no delay was experienced and the entire conduct of the meeting was accelerated.

A number of new standards have been added covering matters aeronautic, research, parts, engines and electrical equipment.

The professional session held during the afternoon of the second day had six papers on its program, of which four were actually ready. Henry R. Sutphen, of the Elco Boat Company, presented a paper dealing with the standardized construction of high-speed motor boats used as submarine chasers, a subject on which he was particularly qualified to speak, as the Elco Company, under his direction, performed the remarkable feat of delivering to the British government in record time 550 80-ft. submarine chasers.

Wing Commander I. W. Seddon, of the British Commission, who has had actual war experience with the Royal Flying Corps, spoke of the design and construction of aircraft in war time and gave his views on the way in which America could aid in establishing the supremacy of the air.

Lieut. Amaury de la Grange, of the French Commission, who also took part in military flying on the other side, spoke of the classification and uses of battle planes and of what America can do in this connection.

H. L. Horning (Mem.Am.Soc.M.E.) presented a paper on Tractors and the Food Problem, discussing not only the immediate demands created by the war, but also those which may be expected to come from the pressure of the coming increase in the population of the world.

An interesting and pleasant feature of the meeting was that constituted by the participation of the highest Government officials in the work of the society. Thus, at the dinner of the society on June 26 in the grand ballroom of the New Willard Hotel, as chief speaker of the evening appeared Secretary of War Baker. The keynote of his speech was that the United States was now engaged in war and a twentieth-century war it was. When the history of this war is finally written it will be shown that we won because we were able to contrive more ingenious engines than our adversary. To reduce the percentage of our losses, we shall have to make use to the fullest possible extent of all the appliances which modern science affords. Aeroplanes would be a great aid in this connection. We must make better and more aeroplanes, so that we can see where our adversaries cannot. Engineers building aeroplanes should realize that they are as truly winning battles as though they were engaged at the front.

Edward A. Deeds (Mem.Am.Soc.M.E.), Chairman of the Aeroplane Construction Board, gave some information regarding the activities of the Aircraft Production Board which was organized on May 6 last and is now under the chairmanship of Howard E. Coffin (Mem.Am.Soc.M.E.).

American Society for Testing Materials

THE annual meeting of the American Society for Testing Materials was held at the Hotel Traymore, Atlantic City, N. J., June 26-29, 1917. Among other activities of the meeting the following papers were presented:

The Committee on Steel, C. D. Young (Mem.Am.Soc.M.E.), Pennsylvania Railroad, Chairman, recommended a number of revisions in both standard specifications and tentative standard specifications and proposed a new tentative standard specification for carbon tool steel.

These specifications cover tool steel in ten classes and three grades determined by the chemical composition specified in a table. In this specification maximum manganese is given for the three grades, A, B and C, respectively, as 0.40, 0.45 and 0.60; phosphorus as 0.02, 0.025 and 0.035; sulphur 0.02, 0.035 and 0.04; and silicon 0.35, 0.35 and 0.25.

In the specification for steel tie plates are described two types of specimen which may be used. The 2-in. specimen of circular cross-section shall have filleted shoulders or threaded ends to fit into the holders of the testing machine in such a way that the line of action of the force exerted by the testing machine shall coincide with the axis of the specimen. Tension-test specimens may also be rectangular in section, in which case there shall be not less than ½ in. in width between the plane sides, and the test piece shall have two parallel faces

as rolled. When the tie plates are of such a design that the rectangular specimens cannot be obtained with out projecting ribs, these shall be planed off before the tests are made.

L. N. Edwards presented a paper entitled The Effects of Grading of Sand and Consistency of Mix upon the Strength of Plain and Reinforced Concrete. This paper describes the methods used and gives the results obtained from tests made upon (1) cylinders in which 12 sands of predetermined gradings were used as sand aggregates; (2) cylinders and reinforced-concrete beams, in the preparation of which five consistencies of mix were used; and (3) cylinders for which the time of mixing was varied from ¼ to 2 min.

The writer came to the following conclusions:

1 The commonly practiced "visual examination" test of sand aggregate for concrete is generally unreliable, since it gives at best only a superficial knowledge of the cleanliness of a given sand. Its adaptation to the determination of grading could be of value to the observer only after long experience in the granulometric analysis of sands.

2 The generally accepted practice of proportioning a concrete mix by volume, as, for example, 1 part cement, 2 parts sand and 4 parts broken stone, is impracticable and unscientific, since it does not take into account the adaptability of the

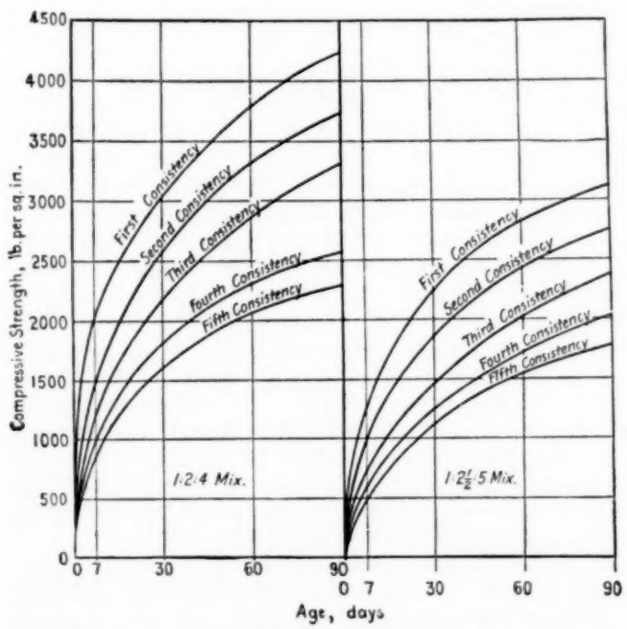

FIG. 1 COMPRESSIVE STRENGTHS OF TEST CYLINDERS OF DIFFERENT CONSISTENCIES

grading of a given sand to the production of a dense, strong and reliable concrete. Proportioning by volume, as commonly used, gives no guarantee of the production of a concrete having a desired strength, hardness, or other physical properties.

3 The strength, toughness and durability of concrete to be secured from the use of a given sand can be determined only by actual test of that sand in a properly prepared concrete.

4 In field operations incident to spading, slicing, or otherwise compacting the concrete, the movement of the water content of the mass is intensified whenever the sand aggregate contains sufficient fine material to hold the cement in suspension by the formation of an adequate amount of sandy paste. The free movement of the water tends to produce an improper distribution of the cement.

Fig. 1 shows the compressive strengths obtained from the tests of cylinders, in which the consistency of the mix was varied from a sticky, semi-plastic to a very wet condition. The sand and stone were of limestone origin.

Several conclusions may be drawn from these results. The use of a quantity of water sufficient to produce a concrete the mortar component of which is of a saturated, sticky, semi-plastic consistency, is for most practical purposes required in order to facilitate economical and efficient placing. The quantity of water is ample for the development of the proper functions of the cement. An increase in the quantity of water used results in a proportionate decrease in the strength of the concrete. This decrease is in no sense a function of the proportions of the mix.

The results of the test on the influence of time of mixing

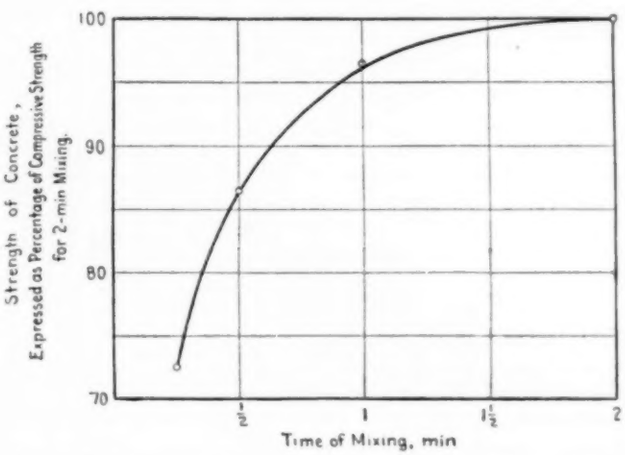

FIG. 2 RELATION OF TIME OF MIXING TO COMPRESSIVE STRENGTHS OF CONCRETE

are shown in Fig. 2. The abrupt change in the direction of the curve at the location indicating the 1- and 2-min. period of mixing, together with the rapid increase of strength shown for mixing periods of less than 1-min. duration, show exclusively the advantage gained by continuing the mixing operation for a period of from 1 to 2 min. after all the materials have been placed in the mixer.

H. A. Gardner presented a paper on Metal Primer Tests reporting the continuation of his researches on painting materials (previously announced at other meetings of the same society).

In previous tests the writer observed that red lead which has been highly oxidized during production and which is, therefore, practically a neutral pigment, is not as well suited for application to metal as red lead which is highly basic in nature and which contains a considerable percentage of litharge. In the present tests it has been demonstrated that incompletely oxidized or highly basic red leads have a superior value. This was shown by an inspection of the paints at the end of three years' exposure.

The tests have further demonstrated that two coats of the neutral iron-oxide paint (chromated or containing zinc chromate or zinc oxide) are superior to two coats of the neutral red-lead paint. It has also been demonstrated that excellent results can be obtained with one coat of a highly basic red lead. Further a comparative durability of one- and two-coat work on an iron-oxide, zinc-oxide paint was demonstrated. The results obtained would indicate that all metal should preferably be given two coats of paint when erected.

The same series of tests covered problems of storage of red

lead in packages. Some of the paint used in this test had been standing for three years in half-gallon cans. When the cans were opened some of the clear oil was removed from each package and ashed to determine the amount of pigment that had gone into the solution.

The results indicate that red leads high in lead tetroxide are quite as soluble in linseed oil as red leads high in lead monoxide. The condition of the paints, observed at the time of opening, would seem to indicate that the softness of red-lead paints after aging is due not solely to the amount of litharge contained therein, but also to the settling properties of the red lead. In other words, red leads of high weight per volume will settle down to the bottom of the cans and become hard; whereas, red leads of low specific gravity are more likely to be maintained in a bulky form.

The results obtained in the storage tests indicate that some chemical action takes place other than that which can be accounted for by the formation of lead linoleate. The writer is of the opinion that the chemical reactions which are partly responsible for the hardening of red-lead paints cause the formation of lead glycerinate, a substance that is recognized as one of the hardest and one of the most durable cementing materials. (Abstracted through the *Railway Age Gazette*, vol. 63, no. 1, July 6, 1917 pp. 13-16, 4 figs., *ge*)

Junior Institution of Engineers

IN THE course of a short paper on Gas Turbines, recently read before the Junior Institution of Engineers, Mr. S. E. Hutson stated that the great hindrance in the way of the development of the gas turbine as a commercial unit was the, at present, insurmountable difficulty of finding a metal which would withstand the extremely high temperature of the gases. He referred to the general lines along which most gas-turbine designers had proceeded, and showed that practically all the experimental machines which had been built were based upon one of three principles. The first involved the use of a combustion chamber lined with refractory material into which some form of fuel was forced, together with such an amount of compressed air as was necessary for combustion. The gases were ignited in this chamber, and were then directed on to the buckets of an impulse wheel after passing through the diverging nozzles. The air and fuel were driven into the combustion chamber by means of pumps or compressors, which took power from the turbine. The second type of turbine was based on much the same principle as the first, but was fitted with a water jacket which surrounded the combustion chamber. The third principle, which the author considered the most feasible and upon which he had himself been working, was described as the regenerative principle. In this case a charge was forced into the combustion chamber, surrounded by the water jacket, and, after combustion, was brought down to a temperature more suitable to the turbine blading, on to which it was passed through nozzles. The reduction of temperature in the combustion chamber was brought about by steam generated in a special type of boiler placed in the path of the gases as they exhausted from the turbine. After briefly describing several of the experimental machines which had been built by British and continental engineers, Mr. Hutson described the designs of a turbine for which he was largely responsible. This design was based upon the regenerative principle, and in many points showed considerable ingenuity; but Mr. Hutson had found himself up against most of the difficulties which had confronted other experimentalists, and, as he admitted, his efforts had been attended with as little success as theirs. In the first place, he had been unable to obtain a suitable material to withstand the high temperature of the gases. He had, moreover, found that in nearly all the experimental turbines which had been built, the fuel and air compressors had consumed a very large percentage of the output of the machines, but on his machine Mr. Hutson had naturally had to resort to the use of a feed pump to get the water into his boiler, which was an additional drain upon the power developed by the turbine. (*The Mechanical Engineer*, vol. 39, no. 1013, pp. 442)

Notes from the Engineering Colleges

Equipment of Laboratories—Investigations in Progress—Changes in Curricula

BELOW is a continuation of the review of professional work being undertaken at the engineering colleges. The articles contain information regarding (1) characteristics of laboratory equipment, (2) tests or researches under way or in prospect, (3) important changes in curricula.

The articles will be concluded next month.

UNIVERSITY OF CINCINNATI

Research Work: The principal investigational work carried on in the Department of Mechanical Engineering was a study of times of explosions of mixtures of natural gas and air. This work was undertaken over a year ago, and results which were thought to be reasonably accurate were secured. The experiments made at that time suggested certain refinements in apparatus, which have been followed during the past year.

The apparatus is an interesting device for obtaining a graphical record of the explosion of a gas in a closed vessel. The principal feature is the use of an oscillograph. The pressure due to the explosion of the gas is made to act directly on a steel diaphragm in the wall of a cylinder. The deflection of this diaphragm displaces a small amount of mercury from a well, causing it to move up a glass tube of small bore. Within the glass tube is a small carbon filament carrying an electric current. The movement of the mercury column along the carbon filament varies the resistance and hence the amount of current flowing in the circuit. Since the oscillograph registers instantly any variation in the current, the building up of the pressure in the cylinder is accurately recorded.

This type of apparatus can be adapted for use on a gas-engine cylinder, since it will follow very rapid fluctuations in pressure and can therefore be used to determine the proper mixture. It was used in the University laboratory to study the time of explosion and the pressure produced by various mixtures of air and natural gas. The advantages obtained by its use were that no carbon deposits could interfere with the moving parts, and that there was practically no inertia effect. The time of the explosion was obtained by sending a 60-cycle alternating current through the oscillograph at the time of the explosion. Then the distance from peak to peak of the alternating-current wave represented to scale 1-60 sec., and the time between various points on the explosion curve could be read directly in sixtieths of a second.

The apparatus consists of an explosion cylinder, gas meter, vacuum pump, and oscillograph, and is shown set up in Fig. 1. A number of tests were made with varying amounts of gas, and different ratios of gas and air. No difficulty was found in adjusting the apparatus to record both the extremely rapid explosions of rich mixtures and the much slower explosions of lean mixtures. Table 1 gives typical results.

In typical curves obtained it is noticed that after the spark is passed the pressure increases very slowly for a time, then there is a rapid increase to maximum pressure.

Another piece of work done was an analysis of a Stuebing lift truck. A series of graphs was obtained of the force required to drag the truck over concrete, wood-block, and steel-plate floor surfaces, with different loads and using plain and roller bearings. The graphs were continuous, showing the starting, maintaining, and stopping forces. Static tests were made to ascertain the strength of various parts of the machine under load. One of the interesting features of the experiments was that the wheels of the truck were caused to revolve while the truck was under load for an equivalent of eighty miles of travel. Chemical analyses of these steels were obtained and microphotographs of a section of each shaft after use in the roller bearings, to show the change in structure of the material. One such microphotograph is shown in the accompanying Fig. 2.

Other work consisted of tests of a 6-ft. plain radial drill when drilling holes of various diameters in cast iron and machinery steels. An apparatus was designed for obtaining the power required to feed a drill and to turn the drill. The apparatus is now complete, but the tests have not yet been made. It is expected that this will be done this summer.

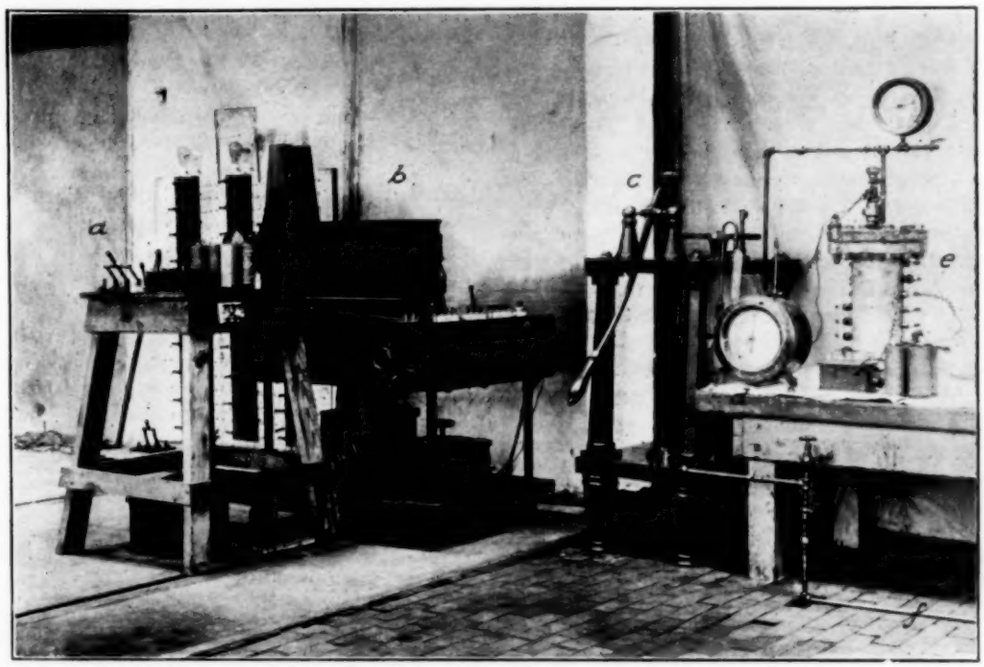

FIG. 1 APPARATUS FOR STUDYING TIMES OF EXPLOSIONS OF MIXTURES OF NATURAL GAS AND AIR
a, Operating Bench; *b*, Oscillograph; *c*, Vacuum Pump; *d*, Gas Meter; *e*, Explosion Cylinder; *f*, Compressed Air.

TABLE 1 TYPICAL EXPLOSION DATA

	No. 1	No. 2
Ratio of mixture	14.6 to 1	10.8 to 1
Volume of natural gas, cu. ft.	0.040	0.080
Initial pressure, lb. per sq. in.	40.0	60.0
Maximum pressure, lb. per sq. in.	190.0	415.0
Time between spark and rapid increase in pressure, sec	0.10	0.05
Time between rapid increase in pressure and max. pressure, sec.	0.23	0.11
Time between spark and max. pressure, sec.	0.23	0.157

Equipment: A new electric dynamometer has been purchased for the measurement of power of internal-combustion engines of high speed, which has a capacity of 100 hp. and 3500 rev. per min. In the design of this dynamometer careful study was made of existing dynamometers at the Automobile Club of America and elsewhere, and it is believed that very delicate tests will be possible on this machine.

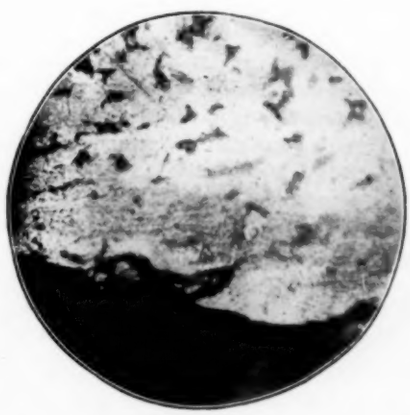

FIG. 2 MICROPHOTOGRAPH OF SECTION OF A SHAFT AFTER USE IN ROLLER BEARINGS (0.20 CARBON, 0.39 MANGANESE)

Several interesting tests were begun upon machine tools. One was of a large new-type milling machine. The principal deflections of the main frame members of a column-and-knee-type milling machine were obtained by means of static loading. This load was first applied in a horizontal direction then 45 deg. with the table. The comparative deflections due to both twisting and bending of the main units were obtained. The power consumed at the cutter in removing cast iron was obtained. The meters, motor and machine were calibrated.

UNIVERSITY OF MICHIGAN

Equipment: Special equipment for the testing of heating and ventilating apparatus; radiator-testing apparatus and other special heat-testing devices; small refrigerating plant for special research work; besides standard instructional apparatus.

The new university power plant contains a 500-kw. cross-compound, non-condensing steam engine; a new 275-kw. turbine of the impulse type is about to be installed.

Experimental Work: Tests on steam radiators to determine coefficients under different circumstances, such as location, and the characteristics of different types of radiators; also to determine the effect of enclosing a radiator in a nook with a grating in front; determination of the rate of heat transfer through an iron coil and through a brass coil located in a tank of water; investigations to determine coefficients for sharp-edged orifices in connection with the measurement of steam flow; investigation of the coefficient of friction of steam flowing in pipes at different pressures and various velocities; investigation of the coefficient of heat transfer through walls of various building materials, notably hollow building tile. Also tests on screw threads, more particularly to determine the size of tapping drill to be used in tapping out nuts up to, say, 1-in. size; and whether threads in the nuts shallower than the full-depth thread will not be just as strong as full-depth threads; what depth will make a combination as strong as the screw at the root of the thread; and stresses on taps when tapping the nuts at different speeds.

VIRGINIA POLYTECHNIC INSTITUTE

Equipment: The engineering laboratories are designed more on pedagogical lines than for research, and for practical utility rather than for scientific research work. There are chemical, metallurgical, physical, and agricultural laboratories.

Metallurgical Laboratory: Volume changes during the hardening and setting of silver, tin and other amalgams; possible connection between the microstructure, Brinell hardness, and the durability of valve and piston packing rings for locomotives.

Graphics Laboratory: Investigations in pure mechanism and special problems in machine design; classification of higher plane linkages, non-circular rolling wheels, parallel motions of straight-line-describing linkage; design of a dynamic balancing machine to weigh quickly and accurately the unbalanced forces of rotating masses.

Pure Mathematics: Mathematical investigation has been completed on the subject of a new transition curve.

Mining Engineering: Determination of the best methods of treating complex ore in Spottsylvania County; examination of natural deposits of ores and minerals.

Experimental Engineering: Investigation of the local power plant for a determination of the cost of heat and power per unit; test of bearing metals and dental alloys, with specially designed impact machine; freezing and oil-penetration tests of cement and concrete; test of brick of the state for the American Society of Testing Materials.

Quite radical changes in the courses of instruction are now being prepared. On account of the improved condition of the primary schools of the state, the degree courses in engineering will be reduced from five years to four years. As the entrance requirements were put on a fourteen-unit basis some years ago, this change can be made at this time.

This Month's Abstracts

THE reference, taken from a paper read before the Aeronautical Society of Great Britain, to a 475-hp. 18-cylinder engine is a good showing of what has been done abroad in the last two years in the way of developing big power plants for aircraft.

A table is reprinted giving standard dimensions of copper tubes for aircraft as adopted by the British Air Board.

In the section Engineering Materials will be found an abstract of an investigation, published by the Bureau of Standards, on the properties of component parts of portland cement. Taken in conjunction with previous data, it forms a valuable contribution to our knowledge of this important material of construction.

The data on iron-aluminum alloys melted in vacuo, taken from the *University of Illinois Bulletin*, are of particular interest as an example of an originally purely laboratory investigation rapidly becoming industrially important—first in the field of electrical engineering and now mechanical.

Attention is called to an abstract of a paper in a German periodical on the influence of radiation on fire temperature.

From the *Journal of the Society of Mechanical Engineers of Japan* are abstracted data on the thermal relations of casting and molding sand, throwing an interesting light on the processes of solidification of metal.

In the section Lubrication will be found data on a series of tests on lubricating oils, interesting both because of the results and because of the novel method adopted by the authors. Particular attention is paid to the determination of the durability of oils.

Those engaged in the design of screw pumps will be interested in the abstract of an investigation on this type of machinery taken from a German periodical. Unfortunately, the original of the article is not now available in this country.

In the section Railroad Engineering there are abstracts of several articles on locomotive engineering. Particular attention is drawn here to the description of the Pennsylvania Decapod locomotive, which embodies some quite novel features for this type of construction.

In the same section will be found an abstract of a paper reporting some tests on corrugated culvert pipe under a sand bed, the significant feature of which is that, among other things, it appears that a sand load over a culvert pipe behaves essentially in the same manner as a grain load in an elevator.

An extensive abstract is made of a paper in the *Proceedings of the German Society of Engineers* on the construction and operation of boilers for intensive service.

The absolute value of entropy and energy is discussed in an interesting manner in a paper presented before the French Academy of Sciences, and from the *Proceedings of the Royal Academy* (Great Britain) is taken an abstract of a paper on the determination of the heat of vaporization of water at 100 deg. cent, and one atmosphere of pressure in terms of the mean calorie.

The Automobile Committee of the Council of National Defense has inaugurated a comprehensive industrial inventory of the automobile industries, including automobile, airplane and watercraft factories, to make available to the Government all possible information regarding their manufacturing facilities and possibilities of expansion for Government work. The inventory is being taken by the industrial inventory section of the Council of National Defense.

REVIEW OF ENGINEERING PERIODICALS

SUBJECTS OF THIS MONTH'S ABSTRACTS

STANDARDIZATION OF COPPER TUBES FOR AIRCRAFT IN ENGLAND.
SUNBEAM-COATALEN AIRCRAFT ENGINES.
CALCIUM SILICATES AND ALUMINATE, PHYSICAL PROPERTIES OF.
IRON-ALUMINUM ALLOYS MELTED IN VACUO.
INFLUENCE OF RADIATION ON FIRE TEMPERATURE.
THERMAL RESEARCHES ON CASTING AND MOLDING SAND.
TRACTOR-ENGINE DESIGN.
GAS TURBINES.
TESTING OF LUBRICATING OILS.
DURABILITY OF OIL, DETERMINATION OF.
SCREW PUMPS.
COMPARISON OF MIKADO AND CONSOLIDATION TYPES OF LOCOMOTIVES.
INTERCHANGEABILITY OF LOCOMOTIVE PARTS.
CORRUGATED CULVERT PIPE UNDER SAND BED.
PENNSYLVANIA RAILROAD DECAPOD LOCOMOTIVE.
AUXILIARY STARTING ARRANGEMENT IN DECAPOD LOCOMOTIVE.
AXLE-GENERATOR BELTS.
BOILERS FOR INTENSIVE SERVICE.
FORMING STEEL BY PRESSING, HAMMERING OR ROLLING.
ABSOLUTE VALUE OF ENTROPY AND ENERGY.
HEAT OF VAPORIZATION OF WATER IN TERMS OF MEAN CALORIE.

Aeronautics

STANDARDIZATION OF COPPER TUBES FOR AIRCRAFT

Difficulties having been experienced by aircraft contractors in obtaining supplies of copper tubing, the causes were investigated, and they were found to be (1) the great variety of sizes called for and (2) the fact that tube makers received orders very irregularly and for small quantities.

Arising out of the investigation, the specification committee of the Air Board has decided that in future copper tube for aircraft contracts will be specified in terms of external diameter and legal standard wire gage. As far as possible tubes of 20 gage (0.036 in.) will be used to the exclusion of all other thicknesses. Where for special considerations it is desirable to use other thicknesses, the choice will, as far as possible, be restricted to gages 16, 18 and 22. The last-named is difficult to manufacture, and will be avoided as far as possible. A new Air Board specification for copper tube will shortly be issued, and will have as an appendix the following list of sizes and gages which the Air Board regard as standard:

20 Gage: $\frac{3}{16}$ in., $\frac{1}{4}$ in., $\frac{5}{16}$ in., $\frac{3}{8}$ in., $\frac{7}{16}$ in., $\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in., 1 in., $1\frac{1}{8}$ in., $1\frac{1}{4}$ in., $1\frac{3}{8}$ in., $1\frac{1}{2}$ in., $1\frac{5}{8}$ in., $1\frac{3}{4}$ in., 2 in.

18 Gage: 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., 2 in.

16 Gage: $\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in., 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., 2 in., $2\frac{1}{2}$ in.

22 Gage: 1 in., $1\frac{1}{8}$ in., $1\frac{1}{4}$ in., $1\frac{3}{8}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., 2 in.

(*Engineering*, vol. 103, no. 2685, June 15, 1917, p. 577)

SUNBEAM-COATALEN AIRCRAFT ENGINES

Description of several types of these engines used in the British Army.

A feature common to all of these engines is that the crankcase and nose piece are cast in one, an arrangement which has the advantage of lightness and rigidity, as well as accessibility. Flywheels are absent.

Overhead valves are used exclusively, with two inlet and two exhaust valves per cylinder.

In the big 18-cylinder engine of 475 b.hp. there are no fewer than six magnetos, each one being enclosed. Two sparks are furnished to each cylinder from two independent magnetos. There are also six carburetors. Shortness of crankshaft and absence of vibration are achieved by the linking of the connecting rods, three cylinders working on one crankpin, the outer rods being linked to the central master one. In consequence of this arrangement, the piston travel in the case of the central row of cylinders is 160 mm., while the stroke of the pistons of the cylinders set on either side is in each case 168 mm.

In the 12-cylinder 350-b.hp. aircraft engine a duplicate ignition scheme is also employed. But this engine is characterized by the passage formed through the center of each induction pipe for the spark plug in the center of the cylinder of each block of three. (Lecture before the Aeronautical Society of Great Britain, abstracted through the *Auto*, vol. 22, no. 23/857, June 8, 1917, pp. 405-406, 4 figs., *d*)

Engineering Materials

PROPERTIES OF CALCIUM SILICATE AND CALCIUM ALUMINATE OCCURRING IN NORMAL PORTLAND CEMENT, P. H. Bates and A. A. Klein

It has been shown previously, e.g., by Rankin (cp. abstract in THE JOURNAL, July, 1916, p. 591), that commercial portland cement is made up essentially of three constituents, viz., tricalcic silicate, dicalcic silicate and tricalcic aluminate. The present investigation has for its purpose the determination of the physical properties of these compounds, alone and mixed in various proportions.

The writers come to the following main conclusions:

1 At early periods the constituents of portland cement of normal composition and manufacture, in the order of their strength-conferring properties, are tricalcium silicate, tricalcium aluminate, and dicalcium silicate.

2 At periods beyond 28 days, the dicalcium silicate gains sufficient strength to place it almost on an equality with the tricalcium silicate.

3 Tricalcium aluminate containing 10 per cent plaster gains practically no strength after the first period at which it was tested; that is, 24 hours.

4 Tricalcium silicate of the purity used in this investigation (90 per cent $3CaO.SiO_2$ in one case and 95 per cent in the other) has all the important properties of portland cement, especially those of the "rate of setting" and strength developed.

5 Dicalcium silicate, such as used in this investigation, sets too slowly and attains strength too slowly to be of any commercial value when used alone.

6 Tricalcium aluminate alone, as used in this investigation, sets too rapidly and attains too little strength to be of any commercial value as a hydraulic cementing material.

7 Tricalcium aluminate, when used to replace about 19 per cent of the dicalcium silicate (which is approximately the amount of aluminate present in portland cement), adds somewhat to the strength of the latter at the later periods. This

mixture when used in addition of 3 per cent of plaster gives lower strengths than the silicate alone, as neat test pieces, but as a 1:3 mortar the strengths are higher than any of the dicalcium-silicate mixtures not containing the tricalcium silicate.

8 Tricalcium aluminate, when used to replace about 19 per cent of tricalcium silicate, did not add to the strength of the latter, showing rather a slight tendency to decrease it. The addition of 3 per cent of plaster gave higher early strengths but lower later ones.

9 Tricalcium aluminate, when used to replace about 19 per cent of mixture of equal parts dicalcium and tricalcium silicate, increased the strength at 24 hours and 7 days, but decreased it at the later periods. The addition of 3 per cent of plaster increased the strength at all periods.

10 Plaster of paris, when added to any of the compounds or mixtures of those studied, generally increased their strength. This effect is more marked at the early periods.

11 The amount of water of hydration of any of the compounds at any period is not a measure of the strength developed, as the dicalcium silicate at one year with 5.5 per cent water of hydration has a strength almost as great as the tricalcium silicate with 11.5 per cent, whereas the tricalcium aluminate with 26.4 per cent has a strength of less than 100 pounds per square inch.

12 The dicalcium silicate hydrates to a very granular porous mass, which allows of ready egress of solutions, and, while it is chemically more resistant to the action of solutions than the tricalcium silicate, yet it furnishes a great number of voids in which salts may crystallize out of solution, and it is consequently very little able to resist the mechanical action of the "freezing out" (crystallization) of salts from solution.

13 On the other hand, the hydrated tricalcium silicate, with its very dense structure, composed of gelatinous (colloidal) silicate interspersed with crystals of lime hydrate, is probably very susceptible to strains produced by alternate wettings and dryings, colloidal material of this kind being subject to considerable volume change resulting from slight moisture changes.

14 It appears, therefore, that the composition of portland cement should be along lines which would not produce a great preponderance of either silicate. The ideal cement should possibly have an excess of the dicalcium silicate, which would give a not too dense hydrated material, gaining strength at later periods. A lesser amount of the tricalcium silicate would furnish the desired early strength and also overcome the excessive porosity of the dicalcium silicate.

15 It is possible to make a cement that will have the properties of portland cement by grinding together the previously separately burned constituents in approximately the amounts in which they exist in portland cement.

16 The function of tricalcium in the finished cement is somewhat problematical. A cement with less than one per cent of alumina has all the properties of portland cement. Such a cement is, however, not a commercial possibility from the manufacturing standpoint, on account of the temperatures and amount of burning involved. To state, however, that the aluminate in the finished cement is of the nature of a diluent or inert material would be drawing a conclusion which, while justified by the present investigation, requires further confirmatory work.

17 The actual products of the hydration are those noted by Klein and Phillips, excepting as noted before the case of the dicalcium silicate, when apparently during the hydration of this compound lime hydrate is formed.

(*Technologic Paper of the Bureau of Standards*, No. 78, June 9, 1917, 38 pp., 21 figs., *eA*)

MAGNETIC AND OTHER PROPERTIES OF IRON-ALUMINUM ALLOYS MELTED IN VACUO, Trygve D. Yensen and Walter A. Gatward

Data of results of experiments carried out at the University of Illinois to determine the magnetic and allied properties of iron-aluminum alloys melted in vacuo. Only the part referring to the mechanical properties of these alloys is reported here.

In general, it has been found that aluminum in the absence of carbon increases the strength of iron in almost direct proportion to the amount added. Furthermore, aluminum appears to affect the toughness of the iron only slightly, for in alloys containing in the neighborhood of 0.1 per cent carbon, aluminum up to 8 per cent has no marked effect either upon the strength or upon the toughness of the iron, which is especially evident in the case of annealed alloys.

The effect of small amounts of carbon is particularly great upon nearly pure iron and increases its strength about 50 per cent. The strength curves for alloys containing small amounts of carbon will consequently be nearly horizontal, and will raise the curves for the more nearly carbon-free alloys at 4 to 5 per cent aluminum, where the effect of carbon seems to be very small. In general, the effect of small amounts of carbon is to conceal the true effect of aluminum on the mechanical properties of iron.

The writers also compare the effect of aluminum upon the mechanical properties of iron with that of silicon. Up to 4.5 per cent, silicon increases the strength much more than does aluminum. On the other hand, 2.5 to 4.5 per cent silicon markedly increases the brittleness of iron; aluminum has no such effect. Furthermore, silicon beyond 4.5 per cent rapidly decreases both the strength and the toughness, while aluminum continues to add strength to the iron without materially affecting the toughness.

It has also been found that aluminum is more powerful as a deoxidizer than is silicon, for it does not commence to combine with iron until all oxides present are reduced. Aluminum forms a solid solution with iron throughout the range studied.

It has been found that the ultimate strength of a 6 per cent aluminum-iron vacuum alloy is 85,000 lb. per sq. in. in the unannealed state and 70,000 lb. in the annealed state. The corresponding figures for pure iron are 48,500 lb. and 35,000 lb., respectively. (*University of Illinois Bulletin*, vol. 14, no. 22, January 29, 1917, 50 pp., 19 figs., *etA*)

Firing

INFLUENCE OF RADIATION ON FIRE TEMPERATURE, Deialein

(*Zeits. d. Bayerischen Revisionsvereins*, July 31, 1916; *Elektrot. u. Maschinenbau*, 35, p. 10, Jan. 7, 1917, Abstract.)

It is usual to determine the temperature of gases above boiler grates without reference to radiation from the burning surface, it being assumed that all the heat developed by the fuel is in the combustion chamber. If allowance is to be made for the lower temperature of the glowing surface, as compared with that in a furnace protected against radiation loss, it must be remembered that when equilibrium is established, the heat corresponding to the reduction of the combustion temperature is equal to the heat radiated at the reduced temperature. If B denote the weight of calorific value H, L the weight of the air needed for combustion, G the weight of gas, t_1 the combus-

tion temperature, c_p the specific heat content of the gas, then $BH + BLc_p t_L = Gc_p t_1$. Also if t_s denote the true fire temperature, t_2 temperature of heating surface receiving radiation, C the radiation constant, R the combustion surface, and ϕ a coefficient giving the fraction of the heat radiated from the grate, which falls on the heating surface, then $G(t_1 c_{p_2} - t_2 c_{p_2}) = C\left\{[(t_s + 273)/100]^4 - [(t_2 + 273)/100]^4\right\}\phi R$. If $\phi = 0$, i.e., if no part of the heating surface is affected by grate radiation and if heat radiated from the grate is not wasted, then $t_2 = t_1$, that is, the actual fire temperature equals the theoretical combustion temperature. The above equation permits of calculation of the radiation ratio $\sigma = (t_1 - t_2)/t_1$ from the measured fire temperature, and hence determination of how much of the calorific value of the fuel is absorbed by radiation to the heating surface. For a given rate of combustion the radiation ratio is practically independent of the fuel. When the rate of combustion is 100 kg. per sq. m., $\sigma = 27$ per cent (ca.); i.e., about 27 per cent of the thermal value of the fuel is conveyed to the heating surface by radiation. At 25 kg. per sq. m. the radiation ratio increases to 44 per cent. The radiation ratio is higher the lower the rate of combustion, and from the relation between fire temperature and radiation ratio it follows that the latter (for a given fire temperature) is higher the better the fuel used. (*Science Abstracts*, Section B—Electrical Engineering, vol. 20, pt. 5, May 1917, pp. 164-165)

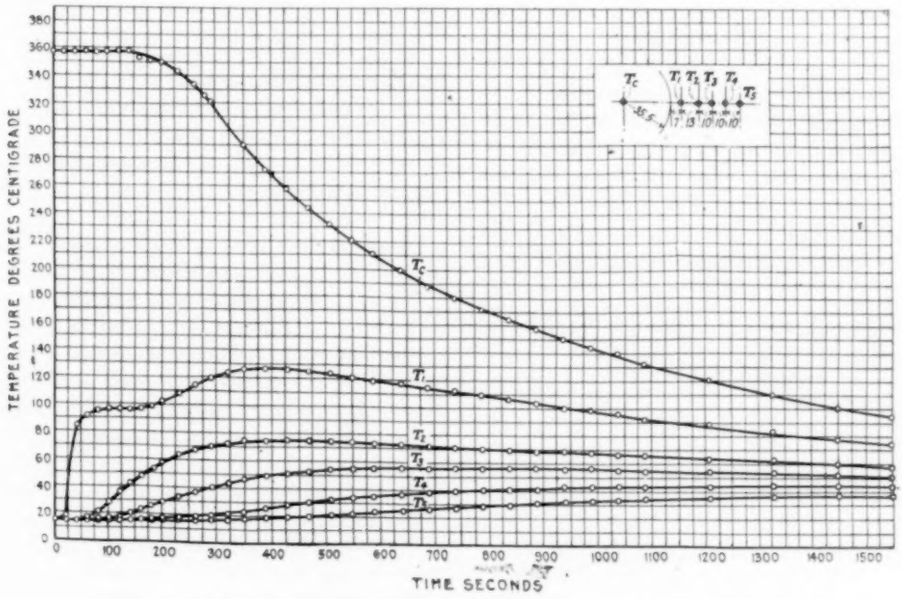

FIG. 1 CURVES OF FLOW OF HEAT IN MOLDING SAND

Foundry

THERMAL RESEARCHES ON CASTING AND MOLDING SAND, Masatosi Okochi

An investigation on the heat conductivity of molding sand.

As an apparatus for the experiment, a wooden box 33 cm. square and 21 cm. deep was filled up with ordinary molding sand. A cylindrical wooden pattern 7.1 cm. in diameter and 15.7 cm. in height was pressed into the sand to half its height at the center of the box. Then molten lead having a temperature of 358 deg. cent. was poured into the mold. Six thermometers were used. The first, nearest to the face of the mold, was a thermocouple, made necessary by the rapid rise of temperature as soon as the molten metal was poured in. The next five thermometers, located respectively at distances of 7 mm. for the first and 20 mm. for the second and equal intervals of 10 mm. for the rest, were of the mercury type.

The molding sand was ordinary river sand with a humidity equal to dry sand plus 10 per cent by weight of water.

Fig. 1 shows data of one of the experiments. This indicates that T_1 rises rapidly as far as about 85 deg. cent. and then rises very slowly until it reaches the maximum of 128 deg. cent. A feature to which special attention is called is that the temperature remains stationary in the range of 96 to 98 deg. cent. This fact was observed in another experiment and is ascribed to the influence of the humidity in the sand. According to the writer, the diminished rate of rise of temperature near the casting is maintained under 100 deg. cent., because a certain fixed amount of heat flowing out of the casting is made use of in evaporating the water contained in the cylindrical layer of the sand between the thermometer and the casting.

In another test there was a very slight amount present, resulting in a temporary rapid rise of temperature. The writer investigates this phenomenon analytically by means of the theory of heat conductivity and comes to the conclusion that castings will prematurely solidify, or, in other words, poured metal will not have sufficient fluidity if there is much humidity in the sand, even if the surface of the mold is thoroughly dried. (*Journal of the Society of Mechanical Engineers*, Tokyo, Japan, vol. 20, no. 47, February 1917, pp. 1-14, 4 figs., *et*)

Internal-Combustion Engineering

TRACTOR-ENGINE DESIGN, C. E. Sargent (Mem.Am.Soc.M.E.)

Paper describing the ideal combination of high compression of less than a cylinderful of air and injection of fuel, expansion to a low temperature and pressure, and control by oil regulation. The writer states that under the most favorable conditions an efficiency of 40 per cent is possible.

In a standard gasoline engine the efficiency at full load is limited first by the low compression, and, other things being

equal, the thermal efficiency increases as the cooling surfaces of the cylinder walls during inflammation. The second loss is caused by releasing the burning gases at an absolute pressure three times as great as it was before compression, eliminating the benefits of expansion so essential for efficiency in other heat engines. The third loss and the greatest limitation to the efficiency of the present engine is the method of reducing the mean effective pressure when developing only a light or idling load. In order to fill the engine cylinder with combustible mixture when its greatest possible output is desired, large inlet valves are provided; yet when less than full load is required, and that is most of the time, the gas is throttled, which not only reduces the compression so essential for efficiency, but puts a back pressure of as much as 10 lb. per sq. in. on the piston. As a result, at least 10 per cent of the power of the engine is required to overcome the braking effect inherent in this form of speed control. Controlling by throttling the intake is a method both simple and cheap, but, as was the case with the early steam engines, is not conducive to economy.

The writer proceeds to the discussion of the use of kerosene as a fuel. He believes that burning kerosene commercially in

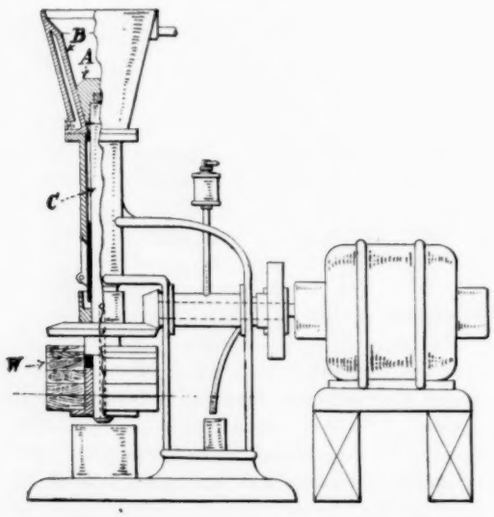

FIG. 2 MACHINE FOR TESTING LUBRICATING OILS

a gasoline engine will never be accomplished until the temperature of the induced charge can be maintained constant automatically, irrespective of the exhaust temperature, compression and cooling effect of throttling. Even if this can be accomplished, the engine capacity will decrease as the temperature is raised to the point necessary for a perfect gas. Regulation by throttling, then, is not conducive to the burning of kerosene.

What the writer suggests is an engine with a 50 per cent longer stroke but of the same bore. Such an engine will weigh a few pounds more than an engine with two-thirds piston displacement, but there will be a net gain of 25 per cent more power from the same fuel. The exhaust will be cooler and the average temperature much less during the working stroke; also the cycle will permit of a speed control that eliminates the back pressure caused by throttling.

The ideal tractor engine (and it is almost real) is one that compresses pure air to a predetermined pressure sufficiently hot to ignite the fuel when introduced, one in which the power and speed can be reduced without introduction of back pressure, in which the fuel used varies with the load and the burning charge is expanded to a greater volume than the air compressed. Every feature embodied in the description of the ideal engine is stated to have been attained. (Paper presented at the Semi-Annual Meeting of the Society of Automotive Engineers, Washington, June 26, 1917, abstracted through *Automobile Topics*, vol. 46, no. 8, June 30, 1917, pp. 889-890, 7 figs., *td*)

Lubrication

TESTING OF LUBRICATING OILS, Hugh K. Moore (Mem.Am.Soc. M.E.) and G. A. Richter

Description of an apparatus for testing of lubricating oils, and data obtained in the tests.

The writers assert that the selection of the most suitable lubricating oil for plant operation depends upon three things: the specific conditions under which the oil is to be used, the cost of lubrication, and the cost of power. This they corroborate by experimental data.

The apparatus used is shown diagrammatically in Fig. 2. It consists essentially of the bearing cone *A*, which is rotated within the conical sleeve *B*, the desired pressure being maintained by a suspended weight *W* on the shaft *C*. The machine is operated by a ½-hp. direct-current motor through a gear drive. The conical sleeve is made high enough to use cones of the different sizes, and is jacketed in order to maintain any desired temperature either high or low at the bearing surface, and also to provide means for bringing the temperature of the bearing to any selected temperature just previous to each successive run in a series.

The power consumption by friction during the operation is measured by means of an ammeter and voltmeter, and the results obtained with different lubricants are directly comparable when the efficiency of the motor is known.

Provision is made for several different methods of testing the oil in question and the writers indicate several such factors. Thus, when the power consumption is a determining factor, the input in watts is plotted against time. In this way the "durability" or "breaking-down" qualities of the oil may be studied. In this case the oil was allowed to circulate in a closed cycle.

TABLE 1 RESULTS OF TESTS OF MACHINE OILS

Number of Oil	Temperatures, Deg. Cent.			Time in Minutes		
	Initial	Final	Increase	Run I	Run II	Average
7	24.0	36.5	12.5	40	40	40.0
13	26.5	30.5	4.0	5	7	6.0
14	22.0	38.5	16.5	47	54	50.5
19	23.0	36.0	13.0	30	32	31.0
23	25.0	38.0	13.0	31	33	32.0
30	23.0	37.0	14.0	35	38	36.5
35	22.0	32.0	10.0	24	24	24.0
36	20.0	37.0	17.0	26	28	27.0

NOTE.—Normal pressure, 1.5 lb. per sq. in. End of groove in cone plugged. No circulation of oil; 3 cc. of lubricant used for each test. Bearing material, brass.

Another method consists in eliminating the oil pump and dropping the lubricant on to the bearing as needed. This determines the consumption of lubricant per unit of time. A third method is to plug the lower end of the spiral feeding grooves leading to the bearing surface, add a certain amount (3 cc.) of oil to the bearing and record the power input each

minute. The machine is allowed to run until the maximum allowable power input is reached, and the power is plotted against time. Such a curve gives information regarding the internal friction (power consumption) and also the "durability" of the oil in question.

In the tests made by the writers it has been found that the oil which stands up for the longest period of time without exceeding the allowable power consumption requires a comparatively higher power input *during* that interval of operation than do the other oils which reach the same predetermined maximum in shorter time. This indicates that although the one oil possesses greater durability, most of the other oils require a much smaller power consumption during their time of operation. Hence, the selection of the most economical oil depends on both the cost of the lubricant and the cost of power. The most economical oil is not necessarily the most suitable, however, since factors such as bearing temperature, gumming and cold test must be considered also.

Data of some of the tests are presented in the form of curves and a table (compare Table 1).

From this table it appears that with the flooded type of bearing, oil 14 is by far the most durable, but its average power consumption is greater than that of the other oils (Fig. 3). On the other hand, oils 19 and 30 last for a shorter interval, but during that interval the average power consumption is much less. Hence, if the cost of power is the deciding factor, oils 19 and 30 are probably more economical to employ than is oil 14, the proportional saving depending on the relative cost of power and of the oil.

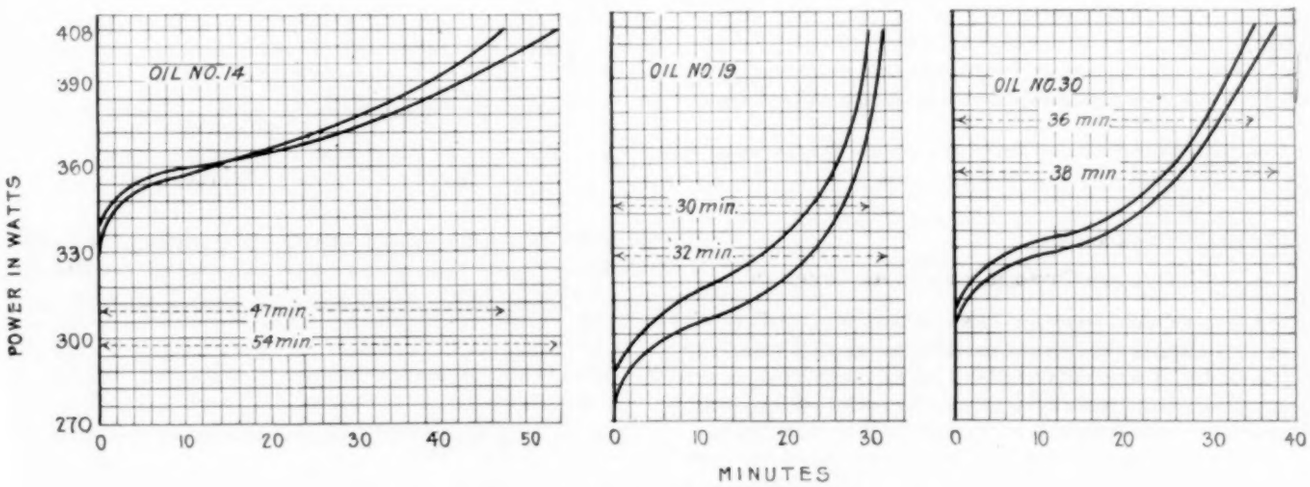

FIG. 3 CURVES OBTAINED IN TESTING LUBRICATING OIL

The tests referred to in this article were carried out at the Research Laboratory of the Berlin Mills Co., Berlin, N. H. (*Metallurgical and Chemical Engineering*, vol. 16, no. 12, June 15, 1917, pp. 692-694, 3 figs., *ed*)

Pumps

INVESTIGATION WITH SCREW PUMPS, A. Pfeiffer

(*Zeits. ges. Turbinenwesen*, Nos. 17-25, 1916. *Elektrot. u. Maschinenbau*, vol. 35, pp. 10-11, January 7, 1917, Abstract.)

The author presents fresh contributions to the theory and design of screw pumps, based on tests carried out in the Munich Technical Institute. Tests undertaken with and without suction and delivery guide wheels, with sharpened and unsharpened guide and runner-wheel blades, show that this type of pump behaves exactly like centrifugal pumps, and that the fundamental equations of turbine theory are applicable to it. In all the tests it was found that the quantity of water q delivered by the runner wheel $= kn$, that is, is proportional to the speed n r.p.m. Further, if H = delivery head, then $H = k_1 n^2$, so that $Q^2 = k_2 H$ or $Q = k_3 \sqrt{H}$. Since $Q \propto n$, $n \propto \sqrt{H}$, the power N of the pump $= Q\gamma H/75 = k_4 H \sqrt{H} = k_5 n^3$. This equation and the above ones between Q, n and H are already well known in connection with Francis turbines and centrifugal pumps. The best efficiency of the screw pump (about 57 per cent) is obtained by using a suction guide wheel with sharpened flat blades approximately perpendicular to the direction of rotation, and with an inclination of the runner-wheel blades to the direction of circumferential velocity of $\beta_2 = 30$ deg. Tests without guide wheel show the most favorable blade angle to lie between $\beta_2 = 25$ deg. and 30 deg. The gain in efficiency as compared with the efficiency without suction guide wheel is so small (about 3 per cent) that it is doubtful whether it is worth providing the guide wheel. The influence of a delivery guide wheel on the efficiency of the pump has yet to be determined, the tests made hitherto bearing only on the most favorable blade angle $\alpha_0 = \alpha_2 = 90$ deg. as determined with suction guide wheel alone. As regards the runner-blade angle β_2 giving highest efficiency, it is found that on increasing β_2 from 10 deg. to 50 deg. almost exactly the same delivery on the same head is obtainable, but the efficiency increases up to $\beta_2 = 25$ deg. or 30 deg., and then decreases again. The revolutions per minute decrease to a minimum at $\beta_2 = 30$ deg. (approx.), and thereafter increase again. The delivery head being predetermined, the blade angle β_2 affects only the speed and efficiency of the pump, and *not* the quantity of water delivered. One therefore selects, for each newly designed runner wheel, that value of β_2 yielding the highest efficiency. The efficiency is 55 per cent with $\beta_2 = 25$ deg. and six sharp, flat runner-wheel blades, and apart from the small increase (about 3 per cent) due to addition of a suction guide wheel. If the pump diagram be constructed for this blade angle, the runner-wheel dimensions may be determined for any delivery head and quantity by observing the ratios $b/D = 0.1835$ and $l/D = 0.25$, of blade width and length to runner-wheel diameter. The diagram must be altered when for predetermined

r.p.m. the ratio b/D exceeds the permissible limit. Results are then altered so materially that fresh tests are needed to give the basis for further calculations. Screw-pump wheels may be built in "series," but at least one from each series should be investigated thoroughly on the test bench. (*Science Abstracts*, Section B—Electrical Engineering, vol. 20, pt. 5, May 1917, p. 168)

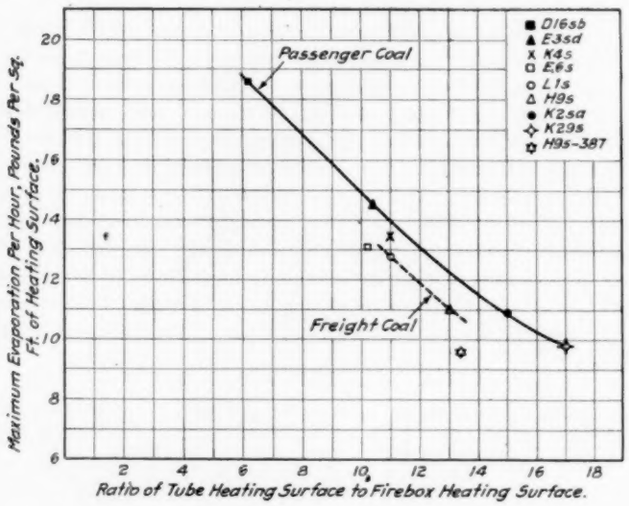

FIG. 4 THE EFFECT OF HEATING-SURFACE DISTRIBUTION ON RATE OF EVAPORATION

Other data obtained in the test (compare Fig. 5) indicate the equivalent evaporation per pound of dry coal. The results for the Consolidation are considerably below those for the Mikado, as the latter on a basis of heating surface shows a range of evaporation between 3 and 16 lb. of water per sq. ft. of heating surface.

Very interesting curves of boiler efficiency are shown in

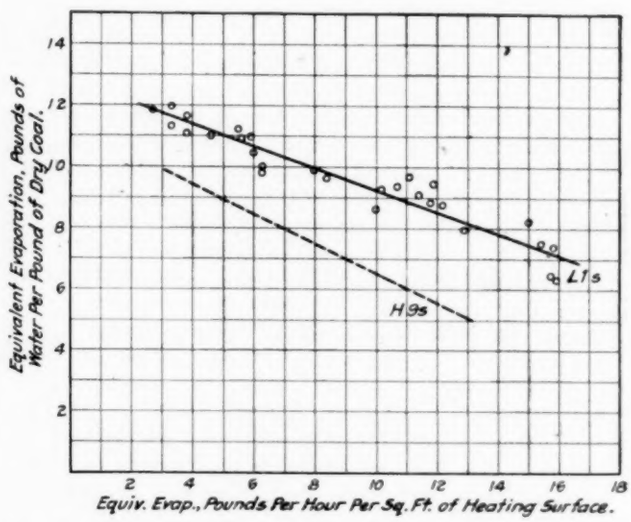
Equivalent Evaporation, Pounds of Water Per Pound of Dry Coal.
L1s
H9s
Equiv. Evap., Pounds Per Hour Per Sq. Ft. of Heating Surface.

FIG. 5 RELATION OF EQUIVALENT EVAPORATION PER POUND OF DRY COAL TO THE RATE OF EVAPORATION

Railroad Engineering

MIKADO AND CONSOLIDATION TYPES COMPARED

Additional data (compare THE JOURNAL, May 1917, p. 471) of tests made at the Altoona testing plant of the Pennsylvania Railroad of a Consolidation 2-8-0 type of locomotive as compared with the Mikado 2-8-2 type. The present article reports especially data obtained from the tests on this latter type.

The tests were all run with a wide-open throttle, the speeds ranging from 7.2 to 31.1 miles per hour with cut-offs from 20 to 80 per cent of the stroke. The coal used was run of mine, as used in freight service on the Pennsylvania, with the heating value between 13,600 and 14,300 B.t.u. per lb.

As regards the *boiler performance*, the maximum steam temperature obtained was 590.6 deg. fahr., the superheat then being 207 deg. From curves given in the original article, it is seen that, as a rule, the smokebox temperatures are below 550 deg., indicating the efficiency of the heating surfaces. On the other hand, the firebox temperatures above 2400 deg. for rates of firing above 85 lb. per sq. ft. of grate per hour are unusually high, and the whole range of firebox temperatures is greater than usual.

From comparisons of tests with seven locomotives at the testing plant, it is apparent that the maximum evaporation is closely related to the fire area or the area of all the tube openings. These seven locomotives indicate that under normal conditions each square foot of fire area of the tubes should give a maximum evaporation of about 7000 lb. of water per hour. But with the improved Consolidation locomotives (H9s) a maximum evaporation of only 5308 lb. per sq. ft. of fire area of tubes was obtained. This was due to certain features of construction of the Consolidation locomotive firebox.

Fig. 4 indicates, however, how the relatively large firebox heating surface makes possible a high rate of evaporation per unit of total heating surface.

Fig. 6. They bring out how rapidly the efficiency of the Consolidation boiler falls off compared with that of the Mikado

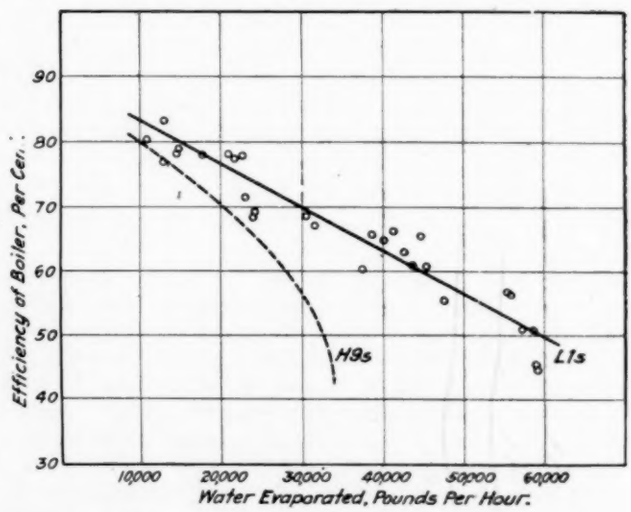

FIG. 6 VARIATION OF BOILER EFFICIENCY WITH EVAPORATION RATE

at rates of evaporation above 2500 lb. per hour. It is stated that for the Mikado the firing rate was between 20 and 175 lb. per sq. ft. of grate, the efficiency of the boiler ranging between 80 and 45 per cent. The maximum evaporation of the Mikado's boiler was 6990 lb. of water per sq. ft. of fire area through the tubes, a rate never before obtained at the test plant.

Engine Performance. The indicated horsepower of the Mikado covered a range between 356, with 20 per cent cut-off and a speed of 7.2 m.p.h., and 2837 at 60 per cent cut-off

and a speed of 31.7 miles per hour. The best steam performance of the Mikado is at a rate of working about 2000 i.hp., the steam rate varying between 19 and 24 lb. The maximum horsepower obtained from the Mikado is greater than that obtained from any other freight locomotive ever tested at the Altoona plant. The curve in the original shows the economical relation of the water rate to the indicated horsepower to be in favor of the Consolidation, probably due to the higher degree of superheat obtained.

On the other hand, in the matter of back pressure the Mikado shows a minimum of less than one pound and a maximum of 16 lb. At the maximum hp. of the Consolidation, which was 1800 in these tests, the back pressure is 8 lb., while the Mikado shows but 4 lb. at the same power. The larger exhaust nozzle of the Mikado (38.3 sq. in. as against 30.9 sq. in. for the Consolidation) probably has an important bearing on this result. Engines of the Mikado type use from 18,500 to 26,100 B.t.u. per i.hp-hr. and convert into work from 9.7 to 13.7 per cent of the heat supplied. In plotting the thermal efficiency of the engines it has been again found that they are the most efficient when developing about 2000 i.hp.

Dynamometer tests have also shown the advantage of the Mikado over the Consolidation for all classes of freight service. In fact, the drawbar pulls obtained indicate that it gives 25 per cent greater pulls at 10 m.p.h. and 60 per cent greater at 30 m.p.h. (Pennsylvania R. R. Testing Plant Bulletin, No. 28, abstracted through the *Railway Age Gazette*, vol. 62, no. 23, June 8, 1917, pp. 1187-1191, 13 figs., *eA*)

Design of Locomotives with Interchangeable Parts

The St. Louis-San Francisco Railway has recently received forty locomotives of modern and heavy types from the Baldwin Locomotive Works, and advantage was taken of the fact that this large order was given at one time. Of these forty locomotives, ten are of the Pacific type for express passenger service, and thirty of the Santa Fe type for heavy freight service. In many respects the two types are similar in construction, and interchangeable details are used when practicable.

Thus, in the case of the Santa Fe locomotives, the machinery and running-gear details are similar to those of the passenger locomotives. The piston valves are interchangeable, and as the frame width and driving journals are of the same dimensions, the driving boxes and shoes and wedges interchange. The same is true of the rear trucks.

The valve gear of the Pacific-type locomotives is of the Baker type and is controlled by the Ragonnet power reverse mechanism. An interesting detail is the pistons, which have rolled-steel heads of dished section with bull rings and packing rings of Hunt-Spiller metal. (*Railway Review*, vol. 60, no. 25, June 23, 1917, pp. 863-868, 9 figs., *d*)

New Electric Locomotives of the Pennsylvania R.R. Co.

In anticipation of the application of electric power to the portion of its main line traversing the summit of the Allegheny Mountains between Altoona and Conemaugh, Pa., the Pennsylvania Railroad has constructed a large electric locomotive.

This locomotive is designed to operate on 11,000-volt, single-phase, 25-cycle current from an overhead trolley. The phase converter changes it to three-phase current for the use of traction motors. These motors, of which there are four, have a rating of 1200 hp. each, giving the locomotive a capacity of 4800 hp. Two motors are mounted on each truck frame; they are geared to a jackshaft impelling the driving wheels through connecting rods, the springs in the gears of these jackshafts being so adjusted as to give the effect of a solid gear up to a tractive effort equivalent to 25 per cent of the weight on drivers. Therefore, under all ordinary conditions, the effect of a solid gear is obtained. (This jackshaft is illustrated in the original article.)

Each truck receives power from its two motors through a spring gear wheel on each side mounted on a jackshaft. Each gear wheel is connected to the three drivers by the usual side rods and the remainder of the drive and running gear is similar to those used for steam locomotives. The spring gear for each truck is of the three-point-suspension type, one point being over the pony truck and the other two points over each frame, consisting of equalizers over each box, elliptical springs between journals and helical springs outside the first and third journals.

The articulation between the motor trucks is of a construction involving a pedestal adjustment to the car center sills. The lower ends of the pedestal legs are connected by means of a tie bar, permitting each truck to rotate around the axis of the center plate without restriction. All bearing surfaces in the articulation are plated with manganese steel. The design is such that pulling and pushing strains between drawbars carry through the trucks and articulation in a direct plane 34½ in. above the rail, so that the cab is entirely relieved of these strains. (*Railway Review*, vol. 60, no. 25, June 23, 1917, pp. 870-873, 7 figs., *d*)

Tests of Corrugated Culvert Pipe under a Sand Bed, Geo. L. Fowler (Mem.Am.Soc.M.E.)

Description and data of tests of pressure produced by a bed of sand. These tests were made in several ways, described in detail in the original article.

The first tests were made with wrought-iron pipes 2, 4 and 6 in. in diameter, 18, 16 and 21 in. long. Each was fitted with a flange coupling at one end, to which a similar flange could be bolted. A sheet of cheap white wood-pulp writing paper was bolted between the coupling flanges. This formed a diaphragm closing the pipe. Wooden plungers were provided that fitted loosely in the pipe and by means of which the pressure could be applied to the paper diaphragm. The amount to burst the diaphragm was noted. Then a fresh diaphragm was put in place and covered to a depth of 1 in. with dry sand. The pressure was again applied and the amount noted. In this way were determined the loads required to burst the paper diaphragms and the results have been plotted in a diagram of bursting pressures, assuming that a circle at the center carrying 60 lb. was the pressure transmitted to the paper and that the annular space outside of it represented the pressure carried by the arching of the sand.

In the diagrams, of which Fig. 7 is given as an illustration, the line *B* is drawn from the ends of the percentage lines at 3½ diameters of such diagram to the edge of the pipe. The angle which this line *B* makes with the side of the pipe is 6 deg. 58 min. 37 sec. for the 6-in. pipe, 6 deg. 57 min. 56 sec. for the 4-in. pipe, 7 deg. 2 min. 39 sec. for the 2-in. pipe, or a total variation of 4 min. and 43 sec. This is a very close agreement and may be considered as an approximation to the angle of arching sand. Further, it tallies closely with the investigations of J. A. Jamieson on grain pressure.

These investigations were supplemented by tests with different arrangements in which lateral thrust of the sand under

a superimposed load and the vertical pressure of the sand were registered by dynamometers. As regards vertical pressure, it was found that the bottom pressure decreased with the depth of sand, but for any given depth the ratio of pressure is nearly constant and rises on approximately straight lines as in the other tests above referred to.

However, as regards the pressure of the sides, an entirely different state of affairs was found. With the depth of 10½ in. of sand above the bottom and 4¼ in. above the center of the side dynamometers, there was a steady rise in the lateral

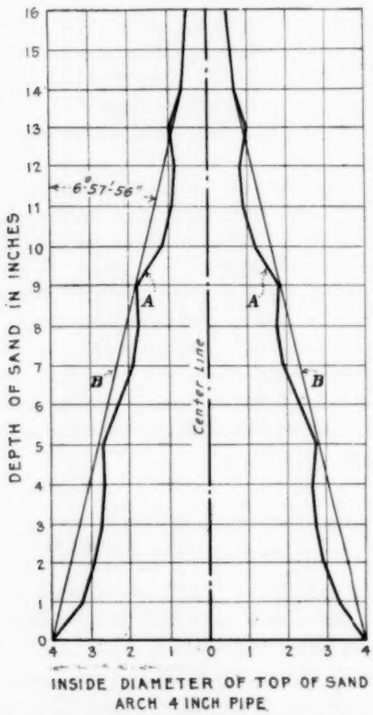

FIG. 7 DIAGRAM OF BURSTING PRESSURES OF PAPER DIAPHRAGM IN TESTS OF CORRUGATED-PIPE CULVERT

thrust as the pressure increased. But when the load was removed from the top the compacted mass of sand continued to exert its side pressure and there was an initial load, and after the depth had been increased and loads were applied there was practically no increase of pressure on the side. In other words the lateral thrust rose rapidly to its maximum under a comparatively shallow depth of sand and then remained practically constant for all increases of depth. It appears from this that on a slightly yielding bottom like that of the type of a corrugated culvert the sand arches and the bottom are relieved of the load.

These tests were checked by another series of tests with a more elaborate equipment. These new tests have emphasized in a marked manner the importance of having the material well tamped against the pipe. It was further found that the sand flows and transmits its pressures without much delay. The influence of a vertical load does not extend very far laterally. During the building up of high pressures the sand yields.

In general, these experiments have corroborated the work of J. C. Meem, who found that in an excavation the lateral pressure increased very rapidly from the top down, reaching a maximum at a point dependent on the angle of repose of the material and then decreasing. It appears that after a certain, as yet undetermined, depth has been reached there can be no further load put upon a culvert pipe by an increase of the depth of cover. And furthermore, such an increase of depth serves directly to protect the pipe against any burden due to an increase of surface loading.

The question next investigated was that of the behavior of culverts under a loading similar to that applied in railway service, where, instead of the application being made on a broad platform covering a considerable area, it is applied through ties of limited width and separated by intervals in which no load is applied to the material. It was found that with the load applied to broad platens, the increase of loading was stopped when the pipe had been deflected by approximately one inch, it being quite evident that the platen would carry a greater load. With the load applied on the ties, the increase was stopped automatically by the ties sinking in the sand and thus refusing to carry more. The result was that the distortion of the pipes under the greatest pressures obtainable was very slight.

These tests have established the fact that under the heaviest load that can be applied to the ties of a railroad track by the wheels of any existing locomotive or car, a 24-in. corrugated culvert pipe having proper depth of corrugation and thickness of metal and buried under a cover of 24 in. of dry sand cannot be deflected beyond its elastic properties of complete recovery of its shape when the load is removed. (*The Railway Gazette*, vol. 26, no. 24, June 15, 1917, pp. 687-691, 7 figs., *e*)

PENNSYLVANIA LOCOMOTIVE OF THE DECAPOD TYPE

In December 1916 the Pennsylvania Railroad built at the Juniata shops a Decapod locomotive having unusual features of construction, and, among other things, a total weight of

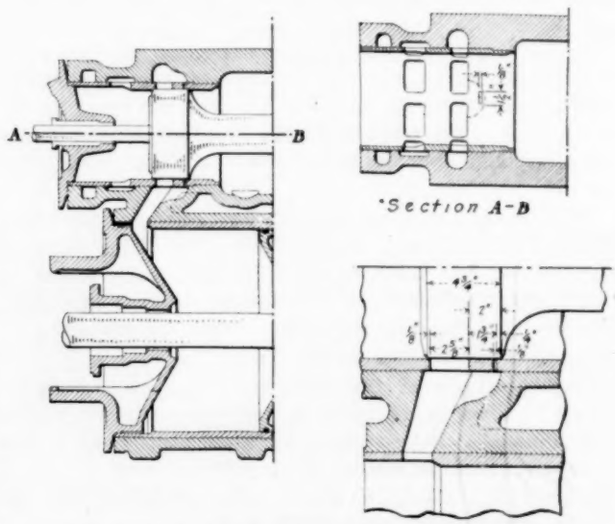

FIG. 8 DETAILS OF THE AUXILIARY STARTING PORT

366,500 lb., a weight on drivers of 344,500 lb. and a tractive effort of 80,640 lb.

Instead of operating at a maximum cut-off of approximately 90 per cent, the valves have been given a steam lap of 2 in. and a maximum cut-off with a reverse gear in the corner of 50 per cent (for reasons explained below).

The desire to secure a maximum tractive effort in proper relation to the weight on drivers necessitates the use of much larger cylinders than are required where 90 per cent cut-off can be obtained. Hence, the cylinders are made 30 in. in diameter by 32 in. long, the boiler pressure being fixed at 250 lb.

per sq. in., so as to take care of clearance limitations which prohibit a still further increase in the diameter of the cylinders.

The use of a 2-in. steam lap necessitates some auxiliary means of admitting steam to the cylinders when the locomotive is standing, in order that it may be started from any position of the crankpins. This difficulty was overcome in a very simple manner. Pockets about 1¾ in. deep are cored out of the inside edge of each steam port in the valve chamber, two in each port. Two ports, ⅛ in. wide and 1½ in. long, are cut through the valve chamber opposite the openings into the pockets in the cylinder casting. This arrangement is shown in Fig. 8, from which it is seen that the auxiliary ports are so placed that their steam lap is ¼ in. These ports serve merely to move the engine until the main ports are opened.

The purpose of the use of 50 per cent cut-off is to eliminate the range of cut-offs within which the water rate of the cylinder is excessive, thereby making possible an increase in the ratio of cylinder power to boiler capacity. (*Railway Age Gazette*, vol. 62, no. 24, June 15, 1917, pp. 1241-1243, 4 figs., *d*)

Analysis of the Axle-Generator Belt Problem

The *Railway Electrical Engineer* announced in April a competition for papers presenting an analysis of the axle-generator belt problem. The two papers which received the first and second prizes, respectively, are published in the article of which this is an abstract.

J. R. Sloan, Engineer Electric Car Lighting, Pennsylvania Railroad, gives the following list of factors affecting belt life in axle-generator service:

1 Lost motion in running gear of cars
2 Type of generator suspension
3 Track conditions and water conditions
4 Size of pulleys
5 Alignment of pulleys
6 Belt fasteners and their application
7 Character of belt.

The writer then discusses in detail each one of these factors. The size of pulleys used is an important factor in the life performance of the belt; the smaller the diameter of the pulley, the less the area of contact and consequently the greater the belt tension for the same amount of power transmitted. Also the smaller the pulley, the greater the relative motion of the fibers of the belt, and the greater the tendency toward internal wear due to friction of the fibers of the belt on each other. To obtain maximum belt service, therefore, the pulleys should be as large as possible.

As regards belt fasteners and their application, the writer states that all types of belt fasteners known to him, with the exception of one, weaken the belt by cutting the fibers and are objectionable in that respect. They have also the disadvantage of introducing a rigid section in the belt.

The writer has a record of approximately 15,000 individual belts, of about thirty different makes, of widths from 4 in. to 6½ in. and plies from four to six, on which various types of fasteners were used. These belts were rubber, friction and canvas. This record shows car number, date and place of application, and date and place of application of the next belt, and the Car Record Office furnishes the mileage between the two dates and places as above. The belts were practically all bought under the same specifications and the record has been carefully studied with a view of determining what make and type of belt is the most suitable.

The evidence is, however, too contradictory to enable one to say that any one make of belt is best, although it has made it possible to eliminate the purchase of certain belts that were decidedly poor. It has also shown that, with operating conditions as they are, a 5-in. 5-ply belt will give service at the least cost per thousand miles. However, the more these records are studied, the more convinced the writer becomes that the reason for low belt mileage is not so much the quality of the belt used as it is the effect of the other causes enumerated above, and it is believed the fastener is the greatest factor, with rough handling of cars next. The perfect belt fastener for axle-generator service has yet to be devised.

The writer's idea of a suitable belt for axle-generator service is a 5-in. 5-ply belt, the yarn being Sea Isle long-fiber cotton woven to weigh not less than 28 oz. per sq. yd., and with the edges straight, the variation in width not to exceed 3.5 per cent plus or minus.

Each inch of width of each ply should have a tensile strength of at least 200 lb. and the plies should be cemented together with a friction of at least 18 lb. per in. of width when tested at a speed of 20 in. per min. The outer surface should be covered with a 1/32-in. layer of good-quality rubber. The complete belt under test load should not stretch over 1½ in. in 18 in.

J. R. Davis, Electrical Engineer of the Baltimore & Ohio, in discussing the same problem states that his experience has shown that alignment and maintenance of suspensions and trucks is a more vital factor in affecting belt life than the difference between the two general types of suspension. In addition, the kinds of belting and fasteners used are also important factors affecting belt maintenance. The following belt-performance data with various types of suspensions are based on an average extending over a period of more than two years. The number of equipments shown, however, are those at present in service.

Table 2 Data on Axle-Generator Belting, Baltimore & Ohio R. R.

Type of Suspension	No. of Cars	Average Belt Mileage
TRUCK SUSPENSION		
Two-point swinging link	44	14,300
Parallel link with belt passing over end frame and under brake beam	24	21,500
Parallel link with open-end truck and inside-hung brake beam	8	35,000
Inverted link	33	15,900
BODY SUSPENSION		
Variable-speed generator with constant-tension device	60	16,900

The experience so far obtained does not permit of reaching any definite decisions with reference to types of suspensions and kinds of belting, but indicates the following:

1 The belting and belt fasteners that have given very satisfactory results with truck-mounted generators may not be at all adapted for body-mounted generators.

2 To secure the best results, with respect to belt life, with body-supported generators of constant-speed type, a belt of special quality is required which should, however, give equally satisfactory results with other types of equipment.

3 Truck-mounted generators of either the two-point swinging type or parallel type, with open-end truck and inside-hung brake beam, thus eliminating all possibility of belt interference, will give longest belt life.

4 The advantages of the body-supported generator as compared with the truck-supported are that it has greater ease for

inspection and making repairs, especially under adverse weather conditions; materially reduced maintenance cost of suspensions and troubles incidental thereto, which will probably be found to be of greater importance than any differences that may be found to exist in the belt life. (*Railway Electrical Engineering*, vol. 8, no. 6, June 1917, pp. 159-151, *ep*)

Steam Engineering

CONSTRUCTION AND OPERATION OF BOILERS FOR INTENSIVE SERVICE, F. Münzinger

(*Zeits. Vereines Deutsch. Ing.*, vol. 60, pp. 933-939, Nov. 11; 958-962, Nov. 18; 1001-1006, Dec. 2, and 1017-1021, Dec. 9, 1916)

The author considers modern boiler practice from the standpoint of cheapness obtained by better utilization of constructional materials and higher stressing of the finished equipment. The influence of turbine development on boiler practice has been far-reaching. The possibility of concentrating very high power in single, compact units led to the development of two-story boiler houses; large overhead bunkers gave way to small pockets directly coal-handling plant became sufficiently reliable; this eliminated much heavy ironwork and saved greatly on the size and cost of buildings. By using comparatively small and cheap feed heaters it became possible to add to overall efficiency while cutting away that portion of the boiler which would otherwise extract heat from the cooled flue gases. A good example of the nature and rapidity of progress in boiler practice is to be found in the power stations erected by the A. E. G. during the period 1908-1912. The boiler-house designs submitted in 1906 contemplated a cheaper construction than had hitherto been employed, and these plans were further improved in respect of the space occupied by feed heaters. By building the economizers of wrought instead of cast iron, and by making them an organic part of the boilers, sufficient saving was effected to outweigh the probably shortened life of the economizer tubes; also, loss in the pipe line was reduced by the shorter pipes and higher steam velocities possible. The first cost of the whole boiler installation and the invariable losses are both reduced considerably. Interesting data concerning boiler installations in South Africa, at Brakpan, Simmerpan, Roshervilledam, and Vereeniging, respectively, are as follows: Date of construction, 1908, 1909-1910, 1911, 1912; weight of boiler, feed heater, and induced-draft equipment, 405, 405, 306, 323 kg. per sq. m. of boiler heating surface; total weight of boiler equipment and steelwork of boiler house, 576, 546, 344, 400 kg. per sq. m. of boiler heating surface; ground space of boiler house, 0.292, 0.287, 0.204, 0.204 sq. m.; space occupied by boiler house and bunkers, 5.70, 5.24, 3.05, 2.24 cu. m. per sq. m. of boiler heating surface in all cases. The cost of boilers in a modern central station working at a high load per unit of heating surface is 25 to 30 per cent of the total installation cost, and the constant losses of the boiler are more serious with the usual type of load curve than in works with nearly constant load. In the case of a public supply station, even the shortest interruption of supply must be avoided at any cost. As a consequence, special desiderata in the boiler equipment are maximum efficiency, adaptability to load variations at minimum capital expense, great reliability and liberal reserve capacity.

Boilers are almost unique in the amount of careful attention which they demand in respect to often contradictory requirements, and there cannot be a boiler which is at once the most desirable for such industrial service as that of a paper mill, and also for central-station work. Too much importance is often attached to a high thermal efficiency, apart from other considerations. The total cost of one ton of steam must be a minimum, and this includes interest and depreciation on the first cost of the boilers with buildings and site, and the cost of coal, repairs, maintenance, and attendance. High efficiency increases in importance with rising price of fuel and longer working hours, but the other factors in "total cost" should never be overlooked. Good efficiency, high steaming capacity, and compact construction are often found in boilers which have serious organic defects, and when an apparently good boiler is discovered, it often happens that some part of the equipment or construction is very unsatisfactory (e.g., defective brickwork or bad grate bars in an otherwise satisfactory boiler).

The steaming capacity, referred to heating surface, has been so much increased that a continuous output of 35 to 40 kg. per sq. m. is nothing unusual in modern boilers. To allow for the heavier depreciation and repairs, the cost of these items should be referred to the weight of steam produced and not to the heating surface. This applies particularly to the fire arch and lining of the combustion chamber. A characteristic of well-designed high-power boilers is the flat course of the upper portion of their efficiency curve, due to the large heating surface exposed to radiation over the grate and to the large economizer surface (as compared with boiler heating surface). In boilers with inclined tubes, radiation from the large volume of luminous flame in the combustion chamber is an important factor, and gives additional efficiency, which is, however, offset to some extent by the better transfer of heat by contact when the gases are guided through and through the tubes by baffle plates. Test data relating to six modern high-power boilers, with heating surfaces ranging from 344 to 770 sq. m., economizers and induced draft, show the evaporation to range from 18 to 53 kg. per sq. m. of heating surface per hour; boiler efficiencies (including superheater) from 67.3 to 81 per cent; and overall efficiencies from 79 to 90 per cent. Tests on two boilers, taken for 24-hour periods without the knowledge of the boiler crew, showed the efficiency to be only about one per cent lower after six months' service than the value obtained during the acceptance test. Heavy brickwork mounting causes an apparent decrease in efficiency during the period at the beginning of the day and a corresponding increase at night after the load decreases. An A. E. G. boiler with plate casing, however, withstood load reduction from 6000 kw. to 2800 kw. in ten minutes without blowing off, although the pressure all day was within 7½ lb. of the safety-valve setting.

The water connections between the bottom drums of vertical and inclined water-tube boilers should be so arranged that the circulating water passes through the lowest parts of the drums. Where boilers have to be put in and out of service very frequently, provision should be made to pass steam from the mains into the lower drums so as to equalize heating and reduce unbalanced stresses. The author shows diagrammatically the water and steam circuits in various boilers, and discusses the relative merits of the several arrangements. Where very reliable load has to be supplied, there is some advantage in preheating the feedwater on part of the boiler heating surface before mixing it with the remainder of the water; part of the boiler then serves the function of economizer. The author considers it of minor importance whether water tubes are straight or curved; it is a little easier to inspect straight tubes, but it is not easier to form a correct estimate of the thickness of scale; probably the chief advantage of straight lines is the simplicity of renewals. In boilers with separate steam and water connections between the upper drums, the steam velocity

may range from 2½ to 8 m. per sec., but if a common connection for water and steam be used, the velocity must be reduced to 0.8 to 2½ m. per sec. (approximately). When water in the front drum is very much agitated by severe working of the front tubes, steam in the front drum is apt to be very moist, and it is given an opportunity of separating if the flow to the rear drum is subdivided and at moderate speed. Moderate steam velocity also favors uniform pressure and water level in the two drums; if any marked pressure difference exists, pressure variations with fluctuating load are transmitted partially through the water tubes, disturbing the water circulation and producing wet steam. Owing to the violent agitation of water in the top drums of water-tube boilers, special measures are generally needed to secure dry steam. The author recommends that in all cases a separate, large steam accumulator should be provided between the top drum and the steam main. The greater the heating surface, the larger must be the top drums, steam accumulator, and all internal water and steam connections of a vertical-tube boiler. It is not enough merely to change the grate surface in order to change the steaming capacity. If properly designed and constructed, this type of boiler will give as dry steam as double-header boiler.

In large central-station boilers an automatic feed regulator is generally installed between economizer and boiler. The economizer is then exposed to all shocks in the feed pipe, and if of cast iron is particularly liable to be damaged. It is preferable to place the regulator in front of the feed heater, especially as this does not affect the actual feeding in any way. Quick-acting control valves naturally cause greater pressure rises than slower valves; air vessels reduce the shocks caused by quick-acting valves, but it is better to use a slow-acting valve. Pressures up to 25 atmospheres were reached in front of a quick-acting valve controlling the feed to a large boiler through a 100-m. pipe line. Higher water velocities and more severe stresses are reached with intermittent than with continuous feed. Steam generated in the feedwater can escape more easily if the control valve is not between economizer and boiler.

The author gives the results of measurements by optical pyrometer on various types of boilers at various loads. The firebox temperatures range from 1067 deg. to 1500 deg. cent. The combustion space of vertical-tube boilers is generally much loftier than that of double-header water-tube boilers, and in order to bring the flames into close contact with the tubes, large arches were often placed over the grate in the early vertical-tube boilers. By preventing direct radiation to the heating surface, such arches increase the temperature of the combustion chamber, favoring complete combustion, but shortening the life of the refractory bricks. In a certain case the furnace lining became useless after 600 working hours due to this cause. The better heat transmission by radiation in an open combustion chamber compensated for the less favorable transmission by contact.

Flue passages must be such that there is maximum "washing" of the heating surface, with minimum loss of draft. Sharp turns, and pockets in which explosive gas mixtures might collect, are to be avoided. Easy access should be provided to rivets, flanges, etc., and for cleansing. The lower drum should foul up very slowly. Manholes should be properly sealed and protected from the heat; suitably placed inspection posts are very useful, as also are openings for pyrometers. Staggered tubes are useful, especially in the back rows, so long as renewals are not made difficult. Tubes should not be set at too small pitch, otherwise the cost of construction is increased, and even flow of gases and good heat transmission are made impossible. The great difference in output per sq. m. of heating surface of economizers differing little in construction is due to the more or less complete distribution of gases over the heating surface. Consequently it is difficult to establish any definite relationship between feed-heating performance and gas velocity. Provision should be made for varying the effect of the superheater at will; refractory plates should be used, and a temperature regulator is desirable where the quality of the coal varies much and often. By placing the superheater in parallel with part of the heating surface, the steam temperature may be kept nearly constant within a wide range of load. The superheater should be surrounded by boiler heating surface rather than by brickwork, otherwise very high steam temperatures may be reached after a sudden decrease in load.

A good fireproof material for boiler masonry must resist high temperatures without melting or softening. Quartz tiles resist intense heat, but are sensitive to temperature changes, and do not resist the fire so well in the direction of their grain as perpendicular thereto. Firebricks composed of SiO_2 and Al_2O_3 are used more commonly. Classification of such bricks as acid or basic is lax and unreliable. A small percentage of such fluxes as Fe_2O_3, CaO, MgO, K_2O lowers the heat-resisting value of the brick. Quartz additions always lower the melting point. Undue importance should not be attached to high Al_2O_3 content, nor should the Seger cone number be taken as a complete index of refractoriness. (*Science Abstracts*, Section B—Electrical Engineering, vol. 20, pt. 5, May 1917, pp. 161-164)

Steel Plant

Relative Methods of Forming Steel by Pressing, Hammering, or Rolling, John Lyman Cox

Paper presenting comparative data on effectiveness and quality of product in very heavy work with hammers and presses. The paper is partly historical.

With the exception of the tube, which is generally made solid, the larger forgings for heavy artillery are usually made hollow, as are marine shafts and other forgings when desired of especially high quality. As it is difficult to manipulate under a hammer, in upsetting and punching, blocks too heavy to be handled on levers, it is customary to bore the ingot with a hole of considerable size and cut from it a hollow block of the proper weight for the job. This involves a considerable waste of material, which may, however, be avoided by proper arrangements.

The width of a hammer anvil block is not great, and if the forging is heavy, it is, in practice, necessary to use an ingot of initial section sufficient to give the requisite weight in the short length that will go between the cheeks of the mandrel housing, for upsetting of heavy blocks under a hammer is impracticable.

The employment of ingots of large cross-section being objectionable for various reasons constitutes one weakness of the hammer, namely, it cannot make great hollow forgings such as are easily producible under the press. It might be urged that an anvil of a special design would permit the use of long billets of less diameter, but the low, unsupported mandrel will not withstand the impact of hammer blows. A 14-in. mandrel on a span of 45 in. to open a hole some 2 in. is about the limit for a hammer.

When made under a hammer of ample power, forgings show test results practically identical with press forgings made

under the same conditions, so long as neither is expanded; but beyond the point where hammer expansion is possible, the advantages are altogether with the press.

Lest it be thought that too much stress is laid upon the advantages of expansion in the manufacture of hollow forgings, the writer cites an experience of the Midvale Steel Company with jackets for a lot of 12-in. steel coast-defense mortars. These were rather short forgings drawn on about a 19-in. mandrel and bored originally with a 20-in. hole. The hole was so small that it had been decided expansion would not pay. But on testing, the jackets gave a great deal of trouble, and it was concluded to bore the ingot with a 14.5-in. hole, expand on a 14-in. mandrel to 16.25 in. in diameter, substitute a 15.75-in. mandrel and expand to 20 in., and after this draw the forgings in the V-die as before. Expansion of the whole increased the outside diameter by only 1⅝ in., giving that much reduction in the V-dies, but on the other hand, the amount of testing was reduced to 21 per cent.

The danger in solid hammered work is always that for economy's sake too light a hammer is used, and the forging left with an imperfectly reduced grain size towards the center.

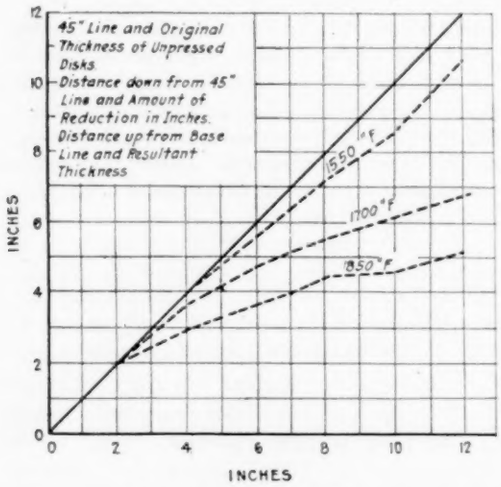

FIG. 9 RELATIVE EFFECTS OF VARIOUS THICKNESSES AND TEMPERATURES FROM EXPERIMENTS ON FORGING PRESSURES

The pressure produced by a hammer is directly proportional to the effective stroke and inversely proportional to the contact area of the dies and to the distance through which the pressure is exerted. The pressure exerted by a press is independent of the stroke, is definite in amount, equaling the net power of the tool divided by the contact area of the dies and the piece being forged.

In press forging the work is turned up after every stroke, thus always presenting a new and smaller contact surface. In cogging down an ingot under a hammer before rounding up begins, several blows are usually struck in the same spot until fear of lapping stops them. Due to the inertia of the part of the ingot beyond the die at the instant the blow falls, there is a tendency to cock up the end of the piece, and the tendency in practice is to let it occur and for the hammer die to cut in more deeply on one side of the ingot than on the other, gradually throwing the axis of the forging out of the axis of the ingot. This does not occur in the press.

As regards the limits of effective reduction, the writer calls attention to the fact that friction between press-die faces and their work is very great, while the longer time of contact as compared with the hammer tends to chill the surface of the forging and to prevent the flow along the die faces. This results particularly in a reduction of the effective thickness of the forging and the increase in the pressure required to forge it. The article gives a table containing ratios of thickness to pressure; in addition to this, Fig. 9 is given, showing graphically the relative effects of the various thicknesses and temperatures employed in a recent series of experiments. The important influence of thickness is corroborated by two full-sized experiments, where, in upsetting at full forging heat 37-in. octagon slices from 43 in. to 13.5 in. in length, it required 8700 tons, which, figured on the areas of the final diameters of 59 in. and 65 in. at the die faces and center, respectively, gives 3.18 tons per contact inch and 2.6 tons at the center. In upsetting the 48-in. round from 45 in. long to 33 in. long, it took only 1.4 tons per sq. in. of contact area and 1.3 tons per sq. in. of median area, on account of the extra thickness of the piece.

With all its advantages, such as convenience of handling and absence of shock, the press has two failings, due to its lack of impact: first, it is harder to get rid of scale, and second, it cannot strike in a mold as large a forging as a hammer its equivalent in other respects. At the Midvale Steel Company they consider a 500-ton press the equivalent of a 2¼-ton hammer; a 1200-ton press the equivalent of a 10-ton hammer, and a 2500-ton press the equivalent of a 25-ton hammer. Yet the 4½-ton hammer can make drop forgings which are beyond the power of a 1200-ton press, and a 2½-ton hammer can about equal it.

The rest of the article is devoted to a comparison of forged and rolled rounds and to armor-plate practice. (*The Blast Furnace and Steel Plant*, vol. 5, no. 6, June 1917, pp. 252-257, 8 figs., *e*)

Thermodynamics

CONCERNING THE ABSOLUTE VALUE OF ENTROPY AND ENERGY, E. Ariès

The writer asserts that there is an initial stage common to all bodies and convenient to be used as a starting point for measuring their entropy and energy. For all bodies this state is defined by the following conditions: The body is at zero absolute temperature, is condensed to the state of saturation, and not subject to any pressure. Any finite increase of volume to which it may be subjected at constant temperatures results only in the body being forced to emit at fixed pressures ($T = 0$, $p = 0$) an inappreciable quantity of vapor (which cannot be measured), so that the entropy and energy of the body remain nil.

On the other hand, every reduction of its volume obtained by means of compression at constant temperature increases its pressure and energy which have at first been nil and now become positive, but its entropy remains at zero. In short, a body when at zero of absolute temperature has an entropy equal to zero and an energy either nil or positive, no matter what may be the pressure to which it is subjected and the volume which it occupies.

Let v be the volume thus occupied by the body at zero absolute temperature. Next, let the body while maintaining the constant volume undergo a succession of increases of temperature dT in such a manner as to bring about some state determined by its initial volume v and by its final temperature T. As often happens, the application of these elementary transformations of one of the laws so fruitful of displacements of equilibrium leads to quite remarkable conclusions.

The law under consideration in this case states that each

transformation at constant volume with a positive variation dT of temperature will produce an increase of entropy, the product $dSdT$ being necessarily positive. From this it follows that the entropy S of a body taken in any state whatsoever determined by its volume and its temperature (v, T) is a positive quantity, except for the case of the zero absolute temperature, when this entropy becomes equal to zero. In each of the elementary transformations thus considered, the variation of energy dU is given by the classical formula

$$dU = TdS - pdv$$

and as $dv = 0$,

$$dU = TdS$$

Since, according to what has been stated above, dS is positive, so will be dU. Each elementary rise dT of temperature will produce an increase of energy, and as the body starts from temperature zero with an energy nil or positive, it will necessarily reach a temperature T and a volume v, i.e., any state whatsoever, with a positive energy.

These two important consequences of the fundamental principles of thermodynamics tend to throw a vivid light on the notions of *absolute magnitude of entropy and absolute magnitude of energy*. It has just been shown that the entropy and the energy of a body can never go below the value which they have at the initial stage, as selected and defined above. And that can only mean that both the entropy and the energy of a body are quantities perfectly determined, usually positive, never negative, which are to be measured from this initial stage.

Furthermore, there is nothing surprising in the conditions under which entropy and energy become zero. In fact, these conditions appear fairly rational. The body maintained at the limit temperature of zero absolute, no matter what pressure it may be under, can have no tendency to transmit heat to the ambient medium, which is at least at the same temperature; hence, it is entropy which cannot undergo any reduction and has to be considered as being zero. If, in addition to that, the body does not support any pressure, then it has no expansive force, though capacity for work. And if it can cede its energy neither in the form of heat nor in the form of work, its energy must also be considered as nil. (*Sur la valeur absolue de l'entropie et de l'énergie*, E. Ariès, *Comptes rendus des séances de l'Académie des Sciences*, vol. 164, no. 20, May 14, 1917, pp. 774-776, *t*)

A Determination of the Heat of Vaporization of Water at 100 Deg. Cent. and One Atmosphere Pressure in Terms of the Mean Calorie, T. Carlton-Sutton

An article describing how the value of the latent heat of vaporization of water at 100 deg. cent. and one atmosphere pressure was measured directly in terms of the mean calorie by using a steam calorimeter that may be regarded as a development of Joly's classical apparatus. It is claimed that a high degree of accuracy has been attained on account of

1 An ice-bath that remains steady for one or two hours
2 A shielding device, by means of which a damp body can be left hanging in a steam chamber without loss or gain in weight; and
3 A determination of the effect of the dampness of the steam.

The temperature of a bulb of thermal capacity K is raised from the freezing point θ to the boiling point Θ by surrounding it with steam, a mass m of steam being condensed on the bulb, where

$$K(\Theta - \theta) = mL.$$

The bulb was then filled with water (of mass M) and the process repeated, a mass m' of steam being condensed, where, omitting small corrections,

$$(K - Ms)(\Theta - \theta) = m'L$$

whence

$$L = \frac{Ms}{m' - m}(\Theta - \theta).$$

i.e., the heat of vaporization is measurable in appropriate calories ($s = 1$) in terms of a temperature difference and the ratio of the masses M and $(m' - m)$.

The author then proceeds to describe the apparatus used and details of the method of experimentation and the necessary corrections applied.

The following results have been obtained: Determination with first bulb, 538.89 mean calories; with second bulb, 538.86 mean calories. These determinations are independent in the sense that they have been made with different bulbs and under different conditions of steam supply, and that any one measurement is used in one series only.

The values may be expected to agree to within seven or eight units in the fifth figure, a degree of accuracy that is confirmed by the experimental figures (see Tables).

The conclusion is, therefore, that the value 538.88 mean calories for the heat of vaporization of water at 100 deg. cent. and one atmosphere pressure is correct to the fourth significant figure for the samples of steam used; and in consideration of the results of Section E IX, it is held that the dampness of these samples has not affected the result to the extent of one part in 5000. (*Proceedings of the Royal Society*, Series A, vol. 93, no. A 649, pp. 155-176, 3 figs., *eA*)

Prizes for Research on Hardness of Metals

The Institution of Mechanical Engineers (Great Britain) has announced that Sir Robert A. Hadfield has placed in its hands the sum of £200, which, with any income thereon, may be awarded at the discretion of the Council of the Institution as a prize or prizes for the description of a new and accurate method of determining the hardness of metals, especially of metals of a high degree of hardness.

The ordinary tests of hardness such as are described in the report of the Hardness Test Research Committee (*Proceedings of the Institution of Mechanical Engineers*, 1916, pp. 677-778) fail to some extent when the hardness of the material exceeds about 600 to 800 Brinell. What is desired is a description of a research for, or an investigation of, some method of accurately determining hardness suitable for application in metallurgical work in cases where present methods partially fail.

The Council of the Institution will consider annually all communications received, but in January 1922 the offer of prizes will be withdrawn. Communications should be addressed to the Secretary, The Institution of Mechanical Engineers, 11 Great George St., Westminster, London, S.W.1, and marked "Method of Determining Hardness," and should reach him at least one month before the first of January in any year.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

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See also Internal-Combustion Engineering.

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2 Physical Aspects, George O. Squier.
3 Mechanical Aspects, W. F. Durand.
4 Aerology, William R. Blair.
5 Theory of an Aeroplane Encountering Gusts, II., Edwin Bidwell Wilson.
6 Engineering Aspects, Jerome C. Hunsaker.
7 Remarks on the Compass of Aeronautics, Louis A. Bauer.
Proceedings of the American Philosophical Society, vol. 56, no. 3, 1917, pp. 161-255, illustrated.

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THE LESS SATISFACTORY MATERIALS OF AIRCRAFT CONSTRUCTION, Capt. G. S. Walpole. The Aeronautical Journal, vol. 21, no. 81, January-March 1917, pp. 50-74, 14 figs.

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†Abstracted in the Engineering Survey in this issue.

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† THE TESTING OF LUBRICATING OILS, Hugh K. Moore and G. A. Richter. Metallurgical and Chemical Engineering, vol. 16, no. 12, June 15, 1917, pp. 692-694, 3 figs.

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GIFT OF WM. PAUL GERHARD

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WATER SUPPLY OF COUNTRY HOUSES. By Wm. P. Gerhard. Reprinted with permission of The Review of Reviews Company, *1914.*

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary, and items should be received by August 16 in order to appear in the September issue.

CHANGES OF POSITION

PAUL FENTON, formerly instructor of machine design at Cornell University, Ithaca, N. Y., has accepted a position as engineer with the Hughes Tool Company, Houston, Tex.

EMILE G. JEGGE, formerly assistant chief engineer of The Arlington Company, Arlington, N. J., has become affiliated with the Du Pont Fabrikoid Company, Newburgh, N. Y.

OLAF T. AVNSOE, mechanical engineer with The Iola Portland Cement Company, Iola, Kan., has become associated with the Cuban Portland Cement Company, Mariel, Cuba.

HOWARD A. GILLAN, formerly assistant engineer with the Union Pacific System, New York, has assumed the duties of purchasing engineer of the Eastman Kodak Company, Rochester, N. Y.

HOWARD G. WRIGHT, superintendent of construction, Anaconda Copper Mining Company, Anaconda, Mont., is at present connected with the U. S. Smelting Company, Salt Lake City, Utah.

WALTER GROTHE has severed his connection with the National Carbon Company, Fremont, O., and has taken up the duties of engineer for the C. L. Best Gas Traction Company of San Leandro, Cal.

ANDREW WESTWATER, formerly with the Columbia River Ship Building Corporation, Portland, Ore., has been appointed chief engineer of the G. M. Standifer Construction Corporation of the same city.

C. R. CADY, until recently industrial engineer with Smith, Hinchman and Grylls, Detroit, Mich., has assumed the duties of manager of the wheel department of The Clark Equipment Company, Buchanan, Mich.

CLARENCE FICHTER has severed his relations with the Chatfield Manufacturing Company, Cincinnati, O., and has accepted a position as combustion engineer with Day and Zimmermann, of Philadelphia, Pa.

JOHN W. WOODCOCK has severed his connection with the Crane Company, of Bridgeport, Conn., and has accepted the position of mechanical superintendent of the Pratt and Cady Company, Hartford, Conn.

JAMES L. KIRSCH, formerly engineer in the estimating department of Struthers-Wells Company, Warren, Pa., is now associated with the Adamson Machine Company, Akron, O., in the capacity of superintendent.

HENRY A. STRINGFELLOW has resigned his position of mechanical engineer with the Sedgwick Machine Works, New York, and has accepted a position as designer with the Epping-Carpenter Pump Company, of Pittsburgh, Pa.

ROBERT R. KEITH, for the past five years in charge of the Sheffield Plant of the Fairbanks-Morse Company, Three Rivers, Mich., has recently accepted the position of plant manager of The Holt Manufacturing Company, Peoria, Ill.

RICHARD M. JAMES, rate setter with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has entered the employ of the Boonton Rubber Manufacturing Company, Boonton, N. J., as foreman of the finishing department.

WALTER S. GIELE, formerly general superintendent of the plants of the Harrison Safety Boiler Works, Philadelphia, Pa., is now connected with the Lebanon Gear and Machine Works, Lebanon, Pa., as vice-president and general manager.

RONALD V. BILLINGTON has become associated with the Interstate Commerce Commission, Kansas City, Mo., as junior engineer. He was, until recently, connected with the engineering department of the Great Western Sugar Company, Lovell, Wyo.

AXTELL A. LLOYD has left the employ of the American Ammunition Company, of New York, and has become affiliated with the Greenfield Tap and Die Corporation, in the capacity of designer, with headquarters at their Springfield, Mass., arsenal.

EDWIN P. DAVIS, for the past two years in the engineering department of the Remington Arms and Ammunition Company, Bridgeport, Conn., has resigned to accept the position of superintendent of the Modern Manufacturing Company of the same city.

ROBERT W. SWEENY, chief draftsman of the car department of the Chicago, St. Paul, Minneapolis and Omaha Railway, Hudson, Wis., has become affiliated with the Minnesota Manufacturers' Association, North St. Paul, Minn., in the capacity of chief engineer.

JOHN B. PRICE has entered the employ of The Mechanical Appliance Company, of Milwaukee, Wis., with temporary headquarters at Chicago, Ill. He was, until recently, connected with the Peerless Electric Company, Warren, O., as assistant superintendent.

SIEGFRIED ROSENZWEIG, formerly mechanical engineer with the Erie City Iron Works, and at the present time consulting engineer of the steam-engine department of the York Manufacturing Company, York, Pa., has also joined the American Spray Company, New York, in a similar capacity.

GEORGE P. RETTIG, mechanical engineer with the Cincinnati Motor Syndicate, Cincinnati, O., has become associated with the office of the army inspector of the Curtiss-Elmwood plant at Buffalo, N. Y. Mr. Rettig is connected with the U. S. Signal Service at large, as inspector of airplanes and airplane-engines.

ANNOUNCEMENTS

JAMES H. HERRON has been elected president of The Cleveland Engineering Society.

CHARLES C. LYNDE, editor of *The Blast Furnace and Steel Plant*, joined the Engineers' Officers Reserve Camp at Fort Oglethorpe, Ga., on May 21.

LEROY T. BYRON has enlisted in the U. S. Naval Reserve Forces as chief petty officer, and is on duty at the Brooklyn Navy Yard, Brooklyn, N. Y.

AMASA M. HOLCOMBE has been assigned to active duty in the small arms division of the Ordnance Department, United States Army, Washington, D. C.

LIEUT. A. LANGSTAFF JOHNSTON, JR., has been called to active duty at the Newport News Shipbuilding and Drydock Company, Newport News, Va., and has temporarily closed his office in Richmond, Va.

AMBROSE SWASEY, Past-President, Am.Soc.M.E., was elected president of the Cleveland Young Men's Christian Association, at the annual election on June 1. He has been very active in the association, and has been its first vice-president for several years.

CAPTAIN ELMER K. HILES has been called into active service of the Fifth Regiment, Engineers' Reserve Corps, and has reported for duty. Captain Hiles is secretary of the Engineers' Society of Western Pennsylvania, and began training for the service last summer at Plattsburg.

JOHN P. FLIPPEN, formerly chief engineer of the C. H. Wheeler Manufacturing Company, Philadelphia, Pa., is now district manager of that company's interests in Western Pennsylvania, Ohio and West Virginia, with offices in Cleveland and Pittsburgh. Mr. Flippen is operating in conjunction with the Baker Dunbar Allen Company, contracting engineers.

It was incorrectly stated in the July JOURNAL that GAIL H. BROWNE left the employ of Ford, Bacon and Davis. Mr. Browne has been transferred from the New Orleans office of the company to their New York office, and is still employed by them as resident engineer on an increased power project for the Lehigh Valley Transit Company at Allentown, Pa.

THE NEW BOOKS

ALL books received by The Journal will be listed under this heading, generally accompanied by brief descriptive notes. Works of special importance to mechanical engineers will be commented on at length by members and others peculiarly qualified by reason of their experience and training.

Franco-American Trade. Report to the American Manufacturers' Export Association by the American Industrial Commission to France. The American Manufacturers' Export Association, 160 Broadway, New York, 1917. Boards, 8 x 10¾ in., 256 pp., 51 illustrations and 10 folding maps.

The American Industrial Commission to France, organized and sent by the American Manufacturers' Export Association in August 1916 (see THE JOURNAL, September 1916, p. 735), has recorded in a handsome volume, just issued, the results of its comprehensive study of the means whereby American resources may best be made available for the reconstruction of the devastated regions, and Franco-American trade relations may otherwise be furthered.

The Commission, whose personnel included Messrs. W. W. Nichols (Chairman), Laurence V. Benét and J. E. Sague of this Society, was composed of twelve members representative of a wide range of interests, and in the forty-odd days spent in the chief industrial centers and ports of the sister republic managed to accumulate the wonderful fund of information which is here set forth with an abundance of illustrations and maps.

The work consists of twenty-five chapters and an appendix, and among the many topics treated are those of trade and tariff, industry and plant construction; industrial and agricultural machinery, labor, syndicates and coöperative societies; chambers and courts of commerce, seaports and shipping, transportation; hydroelectric power; chemical industry; alcohol, social welfare, city planning; education, the devastated regions and their rehabilitation; Belgian reconstruction, etc. Manifestly it has been impossible to give more than a very general outline of any one subject, but it is the belief of the Commission that the facts cited and opinions expressed will throw light not only on present conditions, but on some of the probable developments that may be anticipated as a result of the war. A suggestive bibliography, as well as reports and recommendations of the American Chamber of Commerce in Paris, made at the request of the Commission, are included.

A Discussion of the Principles and Practice Underlying Charges for Water, Gas, Electricity, Communication and Transportation Services. By Harry Barker. McGraw-Hill Book Co., Inc., New York, 1917. Cloth, 6 x 9 in., 387 pp. $4.

The author's aim has been to present, concisely and impartially, and as far as possible in non-technical language, the diverse phases of rate-making for public utilities, including a comprehensive discussion of (1) such corporation and municipal activities as affect service and rates; (2) the trend of public opinion and court and commission decisions; and (3) the most important engineering and economic problems involved, with the hope that it will prove of service to lawyers and legislators, to editorial writers of the daily press, to students of municipal affairs, and to the general public. Contents: Development of Utility Regulation; Utility Privileges and Obligations; Rights of the Public; Product and Service Companies; Some Definitions of Rates and Services; Various Bases for Rates; Details of the Cost-of-Service Study of Rates; Test for Fixed and Operating Charges; Fair Value of a Utility Property; Valuation as an Engineering Task; Appraisal of Land and Water Rights; Reasonable Return, Interest, Compensation for Risk and Attention, Extra Profits; Depreciation as it Affects Utility Rates; Miscellaneous Problems Indirectly Related to Rate-Making; Problems of Railway Rates; Problems of Express Transportation Rates; Rate Problems of Street and Interurban Railway Transportation; Problems of Water Rates; Rate Problems of Gas Utilities; Rate Problems of Electricity Supply Works; Problems of Telephone Rate-Making; Appendices (4).

Modern Underpinning: Development, Methods and Typical Examples. By Lazarus White and Edmund A. Prentis, Jr. John Wiley & Sons, Inc., New York, 1917. Cloth, 6 x 9 in., 94 pp., 48 illustrations. $1.50.

Exhibits by means of photographs and drawings the essential steps in underpinning as illustrated by the methods used in subway construction in New York City. Only enough text to supplement the illustrations is included. Contents: General Aspects; Development of Underpinning and Methods; Shores, Needles, and Foundation Reinforcements; Specific Examples of Underpinning; Appendix.

Steam Piping. Its Economical Design and Correct Layout. By A. Langstaff Johnston, Jr. The Engineering Magazine Co., New York, 1916. Cloth, 5 x 7½ in., 62 pp., 7 illustrations, $2.

Consolidated and revised from a series of articles published in *The Engineering Magazine* in 1915. The factors governing the flow of steam in pipes are analyzed, and a group of curves is presented for use in solving the problems of practical installation and determining the most economical size of pipe to select for any given conditions. Contents: How to Find the Right Pipe Sizes; Special Conditions Affecting Low-Pressure Systems; and Savings Obtainable from Exhaust Steam.

Microscopic Examination of Steel. By Henry Fay. John Wiley & Sons, Inc., New York, 1917. Cloth, 6 x 9 in., 18 pp., 32 full-page plates. $1.25.

While originally issued by the Ordnance Department, U. S. A., and intended for the exclusive use of inspectors of ordnance material, this volume is now published for the use of others interested in the inspection of steel. It presents an outline of metallographic methods, illustrating typical examples. It is intended, not for use as a textbook, but particularly for those who are in need of some help in the interpretation of results.

Steam Power. By C. F. Hirshfeld and T. C. Ulbricht. John Wiley & Sons, Inc., New York, 1916. Cloth, 5¼ x 8 in., 420 pp., 232 figs. $2.

The authors have endeavored to collect in a comparatively small book such parts of the field of steam power as should be familiar to engineers whose work does not require that they be conversant with the more complicated thermodynamic prin-

ciples considered in advanced treatments, and the work is primarily intended for use as a textbook by students of civil engineering and in teaching power-plant operators. Mathematical treatment of the subject has been eliminated to the greatest possible extent.

The Theory of Machines. By Robert W. Angus, B. A. Sc., Mem.Am. Soc.M.E. Second edition. McGraw-Hill Book Co., Inc., New York, 1917. Cloth, 6 x 9 in., 340 pp., 193 figs. $3.

This is a treatise on the principles of mechanism and the elementary mechanics of machines, for use in colleges. It deals with problems of fairly common occurrence, for which graphical solutions have been devised by the author. In the first part of the book a vector method of representing the relative motions of the different parts of a mechanism, called the "phorograph" method, is employed, which, it is stated, appeared in print for the first time in the previous edition. The second part, of much greater difficulty, is devoted to governors, speed fluctuations, flywheel weights, accelerations in machinery and their effects, balancing (new chapter), etc.

The Ventilation Hand Book: The Principles and Practice of Ventilation as Applied to Furnace Heating; Ducts, Flues and Dampers for Gravity Heating; Fans and Fan Work for Ventilation and Hot Blast Heating. By Charles L. Hubbard. Sheet Metal Publishing Co., New York, 1916. Cloth, 6 x 8 in., 218 pp., 137 figs. $2.

A series of questions, answers and descriptions, with illustrations arranged from a series of articles prepared for *Sheet Metal*. The author states that he has endeavored to keep all descriptions and mathematical work well within the understanding of the student and beginner.

Handbook of Casinghead Gas. By Henry P. Westcott. Metric Metal Works, Erie, Pa., 1916. Cloth, 5 x 8 in., 274 pp., 49 illustrations. $2.50.

Information on the processes used for extracting gasoline from natural gas, based on visits to many existing plants and a study of their reports. Contents: General Physical Properties of Casinghead Gas Wells; Construction of Pipe Lines; Measuring Casinghead Gas; Gasoline Plant, Compression Method; Gasoline Plant, Absorption Method; Transportation of Gasoline; Miscellaneous.

Steam Turbines: A Treatise Covering U. S. Naval Practice. By G. J. Meyers. The U. S. Naval Institute, Annapolis, Md., 1917. Cloth, 8 x 12 in., 246 pp., 202 figs. $4.50.

This book has been prepared to serve as an elementary treatise on steam turbines for the use of midshipmen at the U. S. Naval Academy, and deals mainly with types found in the U. S. Naval Service.

Practical Sheet Metal Duct Construction: A Treatise on the Construction and Erection of Heating and Ventilating Ducts. By William Neubecker. The Sheet Metal Publishing Co., New York, 1916. Cloth, 6 x 8 in., 194 pp., 217 figs. $2.

Illustrated descriptions of the various operations involved in the construction and erection of sheet-metal air ducts.

A Handbook for Cane-Sugar Manufacturers and Their Chemists. By Guilford L. Spencer. Fifth edition, enlarged. John Wiley & Sons, Inc., New York, 1916. Leather, 4 x 7 in., 529 pp., 83 figs. $3.50.

The book is divided into two parts, Manufacture of Cane Sugar and Sugar Analysis, and includes a chapter on sugar refining as practiced in the United States. The chemical section of the book, it is stated, has been revised to meet the conditions of the very large factories now in operation.

Central-Station Electric Service: Its Commercial Development and Economic Significance as Set Forth in the Public Addresses 1897-1914, of Samuel Insull. Edited, with an Introduction by William Eugene Kelly. Privately printed, Chicago, 1915. Cloth, 6 x 9 in., 495 pp., 105 figs.

A collection of forty speeches bearing on central-station electric service delivered by the author between 1897 and 1914. The editor states that these addresses are the work of one who has led the way to new conceptions of the economic functions of central-station electric service, and that much information of historical value, some of it never before published, is scattered through the book.

A Manual of Fire Prevention and Fire Protection for Hospitals. By Otto R. Eichel. John Wiley & Sons, Inc., New York, 1916. Cloth, 5 x 7½ in., 69 pp. $1.

An outline of the principles of fire prevention and protection, with indications for their application in institutions housing the sick, based on the personal observation and study of the author, who is Director of the Division of Sanitary Supervisors, New York State Department of Health.

Hendricks' Commercial Register of the United States for Buyers and Sellers. Twenty-fifth annual edition. S. E. Hendricks Co., Inc., New York, 1916. Cloth, 8 x 10 in., 1738 pp. $10.

An annual directory of producers, manufacturers, dealers and consumers connected with the architectural, contracting, electrical, engineering, hardware, iron, mechanical, mill, mining, quarrying, railroad, steel and kindred industries. Intended as a reference book for buyers.

Spon's Electrical Pocket-Book: A Reference Book of General Electrical Information, Formulae and Tables for Practical Engineers. By Walter H. Molesworth. Spon & Chamberlain, New York, 1916. Cloth, 4 x 7 in., 488 pp., 325 figs. $2.

It is stated in the preface that the author's aim has been to treat all of the subjects concisely and to avoid intricate mathematics. Full metric conversion tables are included.

Electric Traction: A Treatise on the Application of Electric Power to Tramways and Railways. By A. T. Dover. Whittaker & Co., New York and London, 1917. Cloth, 6 x 9 in., 667 pp., 523 illustrations. $5.50.

This work is designed for the use of engineers and advanced students. Representative examples of modern tramway and railway practice are included, but detailed accounts of electrification have been omitted and generating stations and transmission lines have not been considered. A number of worked-out examples are given in the text. Contents: Mechanics of Train Movement; Motors; Control; Auxiliary Apparatus; Rolling Stock; Detailed Study of Train Movement; Track and Overhead Construction; Distributing Systems and Sub-Stations; Bibliography on Electrification.

French Measures and English Equivalents. By John Brook. Spon & Chamberlain, New York, 1917. Cloth, 3 x 4 in., 80 pp. $0.40.

Gives the English equivalents (correct to six places) of the metric measures of length and weight and of the old French, Prussian, Austrian and Russian measures of length. Intended for engineers, manufacturers and workmen.